EDITORS

Darrell Fisher
Curtin University of Technology, Australia

Rekha Koul
Curtin University of Technology, Australia

Supatra Wanpen
Udon Thani Rajabhat University, Thailand

EDITORIAL BOARD

Bill Atweh
Curtin University of Technology, Australia

Perry den brok
Eindhoven University of Technology, The Netherlands

Vinesh Chandra
Queensland University of Technology, Australia

Cedric Grieve
Avondale College, Australia

David Lloyd
University of South Australia, Australia

John Malone
Curtin University of Technology, Australia

Chenichei Sid Nair
Monash University, Australia

Kathy Paige
University of South Australia, Australia

Nigel Shepstone
Manukau Institute of Technology, New Zealand

Wahyudi
SEAMEO RECSAM, Malaysia

Bruce Waldrip
University of Southern Queensland, Australia
PREFACE

The Fifth International Conference on Science, Mathematics and Technology Education was held in Udon Thani, Thailand in January, 2008. The theme of the conference was ‘Science Mathematics and Technology Education: Beyond Cultural Boundaries’ and it was organised jointly by the national Key Centre for School Science and Mathematics, Curtin University of Technology, Australia and the Udon Thani Rajabhat University, Thailand.

The conference provided an intellectually challenging and culturally enriching experience for science, mathematics and technology teachers, teacher educators, researchers and administrators from primary, secondary and tertiary education from around the world. Over 120 participants from 15 countries had an opportunity to interact and exchange innovative ideas, research findings and practical implications in the traditional fields of science, mathematics and technology as well as new areas of international significance related to conference theme.

These proceedings are a result of the conference. All papers contained in the proceedings were presented at the conference and consequently submitted to a reviewing process. Each paper was reviewed by at least two referees.

This conference is now providing a supportive environment, particularly for early-career researchers, a number of who presented papers and have papers in these proceedings. The papers have been organised alphabetically.

We have continued our mode of publication as an electronic form. However, people may order a book of the proceedings by contacting one of the editors.
ACKNOWLEDGEMENTS

The conference would not have been possible without the support of the Key Centre for School Science and Mathematics, Curtin University of Technology, Australia and Udon Thani Rajabhat University, Thailand.

We would like to thank all the authors who contributed their papers to these proceedings. We would also like to thank the reviewers and particularly the members of the Editorial Board for their time and diligence.

The book represents contributions from many nations including Australia, Brunei, Canada, Japan, Mauritius, New Zealand, Singapore, South Africa, South Korea, Taiwan, Thailand, Turkey, The Netherlands, United Arab Emirates, and USA. We acknowledge the contributions of people from all these countries. The fields of science, mathematics and technology education research represent a truly international endeavour.

Darrell Fisher, Rekha Koul and Supatra Wanpen
Editors
August, 2008
Table of Contents

1. The Effects of Some Contextual Factors on School Students’ Proportional Reasoning and Solution Strategies
   Othman N. Alsawaie
   United Arab Emirates University, United Arab Emirates 1

2. Teachers’ Perceptions Of Their Principals’ Interpersonal Behaviour And Their Attitudes To The Use Of ICT In Teaching And Learning In Primary Schools In Singapore
   Agnes Ang and Darrell Fisher
   Curtin University of Technology, Australia 15

3. Towards Response-Able Mathematics Education
   Bill Atweh
   Curtin University of Technology, Australia 30

4. An Investigation into the Effectiveness of Using Analogies to Teach and Learn Scientific Concepts
   Florence N. Ballard and David F. Treagust
   Curtin University of Technology, Australia 36

5. Investigating Mathematics Students’ Attitudes Toward Computers and Their Interaction with Achievement and Gender
   Anastasios (Tasos) Barkatsas
   Monash University, Australia
   Vasilis Gialamas
   University Of Athens, Greece
   Katerina Kasimatis
   Pedagogical Institute, Greece 44

6. Effectiveness Of Maea’s Interactive Science Programs In Terms Of African-American Students’ Attitudes, Achievement and Classroom Learning Environment
   Darryl Lee Baynes and Barry J. Fraser
   Curtin University of Technology, Australia 49

7. An Analysis of Secondary School Students’ Perception of Mathematics and Mathematicians in a Developing Country
   Hemant Bessoondyal
   Institute of Education, Mauritius 57

8. Responding To National Curriculum Initiatives
   Deborah Beswick
   Curtin University of Technology, Australia 63

9. Survey Instrumentation, Development, Trialling, Implementation and Evaluation
   Greg Calvert
   Elizabeth College, Australia 70
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Institution(s)</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>10. Designing Learning Activities for a Technologically Integrated Curriculum (Tic)</td>
<td>Vinesh Chandra</td>
<td>Queensland University Of Technology, Australia</td>
<td>76</td>
</tr>
<tr>
<td>11. Design and Technology for Pre-Service Primary Teachers</td>
<td>Vinesh Chandra and Chris Chalmers</td>
<td>Queensland University Of Technology, Australia</td>
<td>81</td>
</tr>
<tr>
<td>12. A Learning Environment Study of Tertiary Classrooms and Students’ Attitudes to Chemistry in Rajabhat Institutes in Thailand</td>
<td>Chanes Kongkarnka and Darrell L. Fisher</td>
<td>Curtin University Of Technology, Australia</td>
<td>90</td>
</tr>
<tr>
<td>13. Computer Classroom Learning Environments and Students’ Attitudes Towards Computer Courses in Tertiary Institutions in Thailand</td>
<td>Kanokporn Charik</td>
<td>Rambhai Barni Rajabhat University, Thailand</td>
<td>100</td>
</tr>
<tr>
<td>14. Students’ Perceptions of Their Learning Environments and Outcomes in Mathematics and Statistics Classrooms at Rajabhat Universities in Thailand</td>
<td>Charoen Chantavong</td>
<td>Udon Thani Rajabhat University, Thailand</td>
<td>110</td>
</tr>
<tr>
<td>15. What Type Of Learning Environment Is My Classroom? Typologies of Turkish Students’ Perceptions of Their Secondary Biology Classrooms</td>
<td>Perry Den Brok</td>
<td>Eindhoven University Of Technology, the Netherlands</td>
<td>120</td>
</tr>
<tr>
<td>16. Subject or Style? Differences in Teacher-Student Interpersonal Behaviour Between Science Teachers and Teachers of Other (School) Subjects</td>
<td>Perry Den Brok and Ruurd Taconis</td>
<td>Eindhoven University Of Technology, The Netherlands</td>
<td>128</td>
</tr>
</tbody>
</table>
17. Underlying Factors Affecting Mathematics Anxiety in School Children
Nicholas Flegg and John Malone
Curtin University of Technology, Australia

18. Proportional Reasoning: A Case Study Highlighting Its Significance in Mathematics Curriculum
John M. Green
University Of Southern Queensland, Australia

19. The Use of Surprise and Sequential Questioning As a Teaching Technique
Cedric Greive and Kevin De Berg
Avondale College, Australia

20. Air-Flow Phenomena and Bernoulli’s Equation: An Example of the Use of Surprise as a Vehicle for Learning
Cedric Greive and Lynden Rogers
Avondale College, Australia

Y. Gulatee & S. P. Maj
Edith Cowan University, Australia
J. Taecho
Nakhonphanom University, Thailand

22. Identifying Social Barriers in Teaching Computer Science Topics in a Wholly Online Environment
Yuwanuch Gulatee and Barbara Combes
Edith Cowan University, Australia

23. Teacher-Student Interactions in a Technology-Supported Science Classroom Environment In Relation To Selected Learner Outcomes: An Indian Study
Adit Gupta
Model Institute of Education and Research, India
Darrell Fisher
Curtin University of Technology, Australia

24. Mathematics Content Knowledge of Pre-Service Primary Teachers: Developing Confidence and Competence
Brenda Hamlett
Curtin University of Technology, Australia

25. Note-Taking Revisited: The Effect of Note-Taking Strategies on Students’ Comprehension in Psychology Classes at Japanese Universities
Sonomi Hirata
Hakuoh University, Japan
Makoto Ishikawa
Joetsu University Of Education, Japan
26. The Laboratory in Science Education: From Theory to Practice
Avi Hofstein
The Weizmann Institute of Science, Israel

27. Science Is Unimaginative And Uncreative! Challenging Pre-Service Primary
Teachers’ Views of Science and Science Teaching Through Explicit Perturbing
Reflections
Christine Howitt
Curtin University of Technology, Australia

Grid
Phongpat Isarakul, Dusadee Sukawat, and Anirut Luadsong
King Mongkut’s University of Technology Thonburi, Thailand

29. An Interdisciplinary Investigation of High School Students’ Approaches To
Learning Science: The Relations Amongst Achievement Goals, Constructivist
Pedagogical Dimensions, Motivational Beliefs and Self-Regulated Learning
Michael R. Iverach and Darrell L. Fisher
Curtin University of Technology, Australia

30. Development of Learning, Teaching and Application of Local Science on
Biodiversity Rajabhat University Network in the Upper North Eastern Region
Varanya Jeeravipoolvarn
Udon Thani Rajabhat University, Thailand

31. The Use of ICT as A Pedagogical Tool in Pre-Vocational Education: A
Mauritian Experience
Vikashkumar Jhurree
Mauritius Institute of Education, Mauritius
Pascal Achille-Sautrelle
BPS College
Hemant Bessoondyal
Mauritius Institute of Education, Mauritius

32. Improving the Learning Environment in Health Science Class: A Case Study
in Thailand
Achara Jinvong
Udon Thani Rajabhat University, Thailand
Darrell Fisher
Curtin University of Technology, Australia

33. Towards a Holistic Model for Professional Development of Science
Educators in Africa Through Distance Education
Esther Kibuka-Sebitosi
University Of South Africa (UNISA)
| 34. Laboratory Learning Environments and Attitude to Biology Classes in Thailand |
| Duangsmorn Kijkosol |
| Udon Thani Rajabhat University, Thailand |
| Darrell Fisher |
| Curtin University of Technology, Australia |

| 35. Student Perceptions of Classroom Environments in Streamed Middle Secondary Mathematics Classes in Australian Christian Schools |
| Peter Kilgour and Tony Rickards |
| Curtin University of Technology, Australia |

| 36. The Use of Mixed Mode Delivery as an Effective Pedagogical Approach in ICT-Rich Classroom |
| Koh Noi Keng |
| National Institute Of Education Singapore Nanyang Technological University, Singapore |

| 37. Identifying Culturally Sensitive Factors of Science Learning Environments in Western Australia |
| Rekha B Koul and Darrell Fisher |
| Curtin University of Technology, Australia |

| 38. Learning Environments and Environmental Education Instrument |
| Rekha B. Koul |
| Curtin University of Technology, Australia |
| David Zandvliet |
| Simon Fraser University, Canada |

| 39. Valued Science and Mathematics Learning In Middle Schooling: Connecting To Students’ Lived Experiences |
| David Lloyd and Kathryn Paige |
| University Of South Australia, Australia |

| 40. Exploring Futures Scenario Writing In Science Learning With Undergraduate Education Students |
| David Lloyd |
| University Of South Australia, Australia |

| 41. Associations Between Students” Abilities to Solve Geometry Problems, Students’ Attitudes and the Learning Environment |
| Rinna K. Ly and John A. Malone |
| Curtin University of Technology, Australia |

| 42. The Impact of Remote Laboratories in Improving Blended Learning in the Science and Technology Arena |
| Steve Mackay and Darrell Fisher |
| Curtin University of Technology, Australia |
43. Evaluations and Quality: A Symbiotic Union for Evidence-Based Decision Making To Affect Change
Chenicheri Sid Nair and Lorraine Bennett
Monash University, Australia

44. A Digital Implementation of Integrator by FPGA for Application with Teaching and Learning in Thai Electronic Classroom
Chaiyong Pagarapun
Udon Thani Rajabhat University, Thailand

45. E-Learning Issues: Probing Pedagogy, Interface and Culture
Jeremy Pagram and Penporn Pagram
Edith Cowan University, Australia

46. Assessment Through Exhibition: Connecting Fourth Year Primary/Middle Science and Mathematics Education Students to Place
Kathryn Paige
University Of South Australia, Australia

47. The Two Cultures and Hidden Truths: A Personal Tribute
Bill Palmer
Curtin University of Technology, Australia

48. The Effectiveness of Constructivist Teaching On Improving Learning Environments in Thai Secondary School Science Classrooms
Panomporn Puacharearn
Rajabhat Nakhornsawan University, Thailand
Darrell Fisher
Curtin University of Technology, Australia

49. Creating a Networking Process Among University Staff, Supervisors and Schools for Improving In-service Teachers’ Competencies
Panomporn Puacharearn
Rajabhat Nakhornsawan University, Thailand
Darrell Fisher
Curtin University of Technology, Australia

50. A Study Of Science Learning Achievement Of Prathomsuksa 3 Students In Hydrologic Cycle Using Clouding And Raining Demonstration Accessories
Patcharin Sripaisaan
St. Mary’s School, Thailand
Chutima Intarapanich
Udon Thani Rajabhat University, Thailand

51. Effects of Providing Activities Based On Increasing Efficacy of Forages for Dairy Cows of Small Holder Farmers at Udon Thani, Thailand
Montha Phuedam
Udon Thani Rajabhat University, Thailand
<table>
<thead>
<tr>
<th>Title</th>
<th>Authors</th>
<th>Affiliations</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>52. Teacher Interpersonal Behaviour: It’s Influence on Student Motivation in Science</td>
<td>Catherine Reid and Darrell Fisher</td>
<td>Curtin University of Technology, Australia</td>
<td>437</td>
</tr>
<tr>
<td>53. Using Industry-Based Needs Analysis to Inform Curriculum Development: A Case Study from the Tourism Industry</td>
<td>Wilailak Riach</td>
<td>Udon Thai Rajabhat University, Thailand</td>
<td>446</td>
</tr>
<tr>
<td>54. Teachers’ Interpersonal Behaviour in Secondary Schools</td>
<td>Hunus Riah, Nurdianah Goh Abdullah, Sekolah Menengah Sayyidinah Othman Brunei Darussalam, Brunei</td>
<td></td>
<td>452</td>
</tr>
<tr>
<td>55. Learning Environments On “One District: One Dream School” Project in Science Classes in Thailand</td>
<td>Toansakul Santiboon</td>
<td>Udon Thani Rajabhat University, Thailand</td>
<td>461</td>
</tr>
<tr>
<td>56. An Interactive Whiteboard in the Singapore Classroom: The Impact on Students</td>
<td>Jimmy Seah</td>
<td>Nanyang Technological University, Singapore</td>
<td>468</td>
</tr>
<tr>
<td>57. Understanding: An Enigma</td>
<td>Nigel Shepstone</td>
<td>Manukau Institute of Technology, New Zealand</td>
<td>472</td>
</tr>
<tr>
<td>58. The Role of Teacher-Student Interpersonal Behaviour in Improving Mathematics Teaching and Learning in Thailand</td>
<td>Lert Sitthikoson and John Malone</td>
<td>Curtin University of Technology, Australia</td>
<td>476</td>
</tr>
<tr>
<td>59. Gender and ICT: Toys for the Boys or Pearls for the Girls?</td>
<td>Sarah Snell and Catherine Snell-Siddle</td>
<td>Universal College Of Learning, New Zealand</td>
<td>485</td>
</tr>
<tr>
<td>60. Mobile Technologies: Enhancing Possibilities for Learning</td>
<td>Sarah Snell and Catherine Snell-Siddle</td>
<td>Universal College Of Learning, New Zealand</td>
<td>490</td>
</tr>
<tr>
<td>61. Writing Chemistry and the Four Skills: An Ongoing Process</td>
<td>Steven Graham</td>
<td>Udon Than Rajabhat University, Thailand</td>
<td>495</td>
</tr>
</tbody>
</table>
62. Primary Science Curriculum. The Constraints and Limitations of Learning and Teaching an ‘Over-Stuffed’ Science Curriculum: A Case Study from Fiji.
Wili Suluma
The University of the South Pacific, Fiji 502

63. A Study of a Nation-Wide Pilot Program in School Mathematics
Kevin Swincicky
North Albany Senior High School, Australia
John Malone
Curtin University of Technology, Australia 509

64. Content Knowledge And Science Teaching: How Confident Are UAE Prospective Elementary Science Teachers?
Hassan H. Tairab
United Arab Emirates University, United Arab Emirates 516

65. International Field Schools as International Education: An Ethnographic Approach
Andra P. Thakur
Udon Thani Rajabhat University, Thailand 526

66. Primary Educators Competency in Language, Vocabulary and Technicalities in the Curriculum and Instruction of Mathematics in Schools (Primary) In Fiji
Iowane Ponipate Tiko
Lautoka Teachers College, Suva, Fiji Islands 533

67. Reflections on the Development of a Web-Based Course to Support EFL Learning for Pre-Service Teachers in Thai Rajabhat University: A Case Study
Vijittra Vonganusith
Sakon Nakhon Rajabhat University, Thailand
Dr Jeremy Pagram
Edith Cowan University, Australia 543

68. Peer Review: Our Experiences
Wahyudi and Cheah Ui Hock
Seamo Recsam, Malaysia 553

69. Students’ Perceptions of Assessment Process: Questionnaire Development and Validation
Bruce G. Waldrip
University Of Southern Queensland, Australia
Darrell L. Fisher
Curtin University of Technology, Australia
Jeffrey P. Dorman
Australian Catholic University, Australia 561
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Authors</th>
<th>Institution</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.</td>
<td>Perspectives on Early Career Science Teachers' Work Lives</td>
<td>Gillian Ward</td>
<td>The University of Auckland, New Zealand</td>
<td>569</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Darrell Fisher</td>
<td>Curtin University of Technology, Australia</td>
<td></td>
</tr>
<tr>
<td>71.</td>
<td>Becoming “The Provider” Identity: Peer Discourses Of Masculinities in School Cultures</td>
<td>Rebecca Wilson</td>
<td>Curtin University of Technology, Australia</td>
<td>579</td>
</tr>
<tr>
<td>72.</td>
<td>An Investigation of Students' Achievement in Biology, Their Attitudes, Motivational Traits and Socio-Psychological Interactions in Single-Sex Schools</td>
<td>Bob Chui-Seng Yong</td>
<td>Universiti Brunei Darussalam, Brunei</td>
<td>585</td>
</tr>
<tr>
<td>73.</td>
<td>The Effects of Reciprocal Teaching on Thai High-School Science Students’ English Reading Comprehension</td>
<td>Yuwadee Yoosabai and Saegchan Hemchua</td>
<td>Srinakarinwirot University, Thailand</td>
<td>594</td>
</tr>
<tr>
<td>74.</td>
<td>Pre service Mathematics Teachers’ Perception Toward Model Courseware: A Malaysian Perspective</td>
<td>Effandi Zakaria, Md Yusof Daud, Zolkepeli Haron and Mohamed Amin Embi</td>
<td>University Kebangsaan, Malaysia</td>
<td>600</td>
</tr>
</tbody>
</table>
ABSTRACT

This study aimed at investigating the effects of content, type of quantity, shape, and unit on school students’ proportional reasoning and their strategies in solving proportion problems. It, also, aimed at comparing the performances of males and females on proportion problems. Further, it tested the possibility of the transfer of proportional reasoning from problems that elicit an intuitive understanding of proportion to problems that do not.

Five problems with different contexts were developed for this purpose. Data was collected from 2,370 students in grades 7, 9, and 11. Results showed a generally low level of proportional reasoning abilities. Students were found to perform better on problems involving discrete quantities than on those involving continuous quantities. Shape, content, and unit were found not to have effect on proportional reasoning. Students in grade 11 outperformed those in grade 9 who, in turn, outperformed students in grade 7 on problems involving discrete quantities. However, no significant differences due to grade were found on other problems. Males outperformed females on the most difficult problems in grades 9 and 11. However, no significant difference was found in grade 7 due to gender. Students tended to use unit strategy with problems where units made explicit more than in other problems. In contrary, additive strategy was used the least with these problems. Proportional reasoning was found to transfer from problems that elicit an intuitive understanding of proportion to problems that do not for students in grades 9 and 11 but not for those in grade 7. Some instructional recommendations and suggestions for future research are presented.

BACKGROUND

Proportional reasoning is considered the basis for learning Algebra and other advanced mathematical subjects (Pearn, & Stephens, 2004; Nabors, 2002). It is crucial not only for solving mathematical problems but also for solving problems in other contexts such as physics, chemistry, business and others, (Heller, Ahlgren, Post, Behr, & Lesh, 1989). The National Council of Teachers of Mathematics (NCTM) has recognized the importance of learning proportion and called for helping students deeply understand proportionality to solve problems flexibly (NCTM, 2000).

The fact that many aspects of life function according to proportional rules makes proportional reasoning ability so useful. However, the development of proportional reasoning is one of the most challenging aspects of mathematical thinking because it requires understanding different concepts related to rational numbers such as comparison, equivalence, the relations between the unit and its parts, and dividing small numbers by larger ones (Vergnaud, 1988). Although the concept of proportion is taught early in school, research findings point out that students face great difficulties with proportional reasoning (Cai & Sun, 2002; Singh, 2000) even at the university level (Ilany, Keret, & Ben-Chaim, 2004).

Proportional reasoning is a form of mathematical reasoning that involves two types of thinking: quantitative and qualitative. The quantitative thinking resides in determining an unknown value from within 4 values usually involved in proportion problems. Regardless of the type of problem, all proportional relationships can be expressed as \( y = ax \). Qualitative thinking which proceeds quantitative thinking involves determining the direction of the answer. In this case, qualitative thinking requires interpreting the meanings of the two ratios, storing the interpretation mentally, and then comparing them based on pre-set criteria. This process requires mental abilities equivalent to the Piaget’s level of abstract operations of cognitive development (Lo & Watanabe, 1997).

This kind of processing requires multilevel thinking that differs from the algorithmic approach that involves using specific rules in solving problems. Actually, Piaget’s concept of abstract thinking relates to the individual’s ability to reason proportionally (Bar, 1987), and usually problems on ratio and proportions are used to determine the stage of abstract operations (Roth & Milkent, 1991). Further, proportional reasoning ability is considered an important sign of individual’s cognitive development (Cramer & Post, 1993).

Piaget has described three stages of proportional reasoning development. In the first stage, the student does not recognize ratio dependence and solves problems by guessing. In the second stage, the student recognizes the objective dependence and seeks solutions by estimation and later by arithmetic, but she/he assumes that the
change in a quantity produces the same change in the other. In stage 3, the student discovers proportionality and applies it in problem solving (Vollrath, 1986).

However, proportional reasoning is more complex than what Piaget describes because there are cognitive, developmental, and contextual factors that affect individual’s ability to reason proportionally (Tournaire & Pulos, 1985). In contrast to what Piaget believes, Kolodity (1977) found that most of first year university students have not reached this stage. Similarly, Lawson and Renner (1975) documented that 40-75% of post secondary students don’t operate on Piaget’s abstract level.

Because of the great importance of proportional reasoning, it received a great deal of attention from researchers. Research has dealt with students’ difficulties in solving proportion problems in addition to the cognitive, developmental, and contextual factors that play a role in proportional reasoning. Some research studies revealed that many students do not recognize that the relationship between the two terms of a ratio is multiplicative (Hart, 1984; Karplus, Karplus, & Wollman, 1974), rather they consider it to be additive. For example, when a student solves for \( x \) in the proportion \( \frac{5}{8} = \frac{10}{x} \), she/he thinks this way: \( 8 - 5 = 3 \), then \( x - 10 \) should be 3, so \( x = 13 \).

Other studies found that students face difficulties in finding multiplication relationships between non-integer numbers. For example, in a missing value problem such as \( \frac{A}{B} = \frac{C}{x} \) where \( x \) is the unknown, there are two ways to solve for \( x \): the rate of change \((x = C \times \frac{B}{A} \text{ where } B \div A \text{ is the rate of change})\) and the factor of change \((x = B \times \frac{C}{A} \text{ where } \frac{C}{A} \text{ is the factor of change})\). It was found that students tend to use the rate of change or the factor of change whichever is an integer, and additive reasoning if both are not integers (Karplus, Pulos & Stage, 1983; Post, Cramer, Behr, Lesh, & Harel, 1993).

Due to the mechanical way of teaching cross multiplication algorithm, some researchers have found that many students, who solve problems that require direct use of it, don’t understand proportion (Hoffer, 1988; Lesh, Post, & Behr, 1988). This conclusion was strengthened when some students were found to apply this algorithm in solving a problem like: (the ratio of boys to girls in a class is 2:3. If the number of boys is 9, what is the number of all students in the class?). In solving this problem, students applied the algorithm like this:

\[
\frac{3}{2} = \frac{9}{x}, x = \frac{9 \times 2}{3} = 6 \text{ not recognizing that } 6 \text{ is even less than the number of boys.}
\]

Singh (2000) found that high scores in traditional math exams were not indicators of ability to solve complex and unfamiliar proportion problems. On the other hand, Saunders and Juesenathadas (1988) conducted a study to test if students use their proportional reasoning abilities in other subjects they study. The study revealed that even when students have such abilities, they can’t use them with unfamiliar content such as abstract science concepts.

Moreover, the effect of contextual factors on proportional reasoning was studied. Heller, Post, Behr and Lesh (2003) conducted a study to test the effect of two context variables, type of rate and the familiarity of the problem. In addition they studied the effect of understanding rational numbers on solving directional and numerical proportion problems. They also compared students’ performance on these problems and others on fractions that are equivalent structurally and/or numerically. Four types of rate problems were used in this study: mixture, speed, linear density, and scaling.

The study revealed that the most difficult directional problems were the scaling problems. An interaction was found between the type of rate and the familiarity of problem as students faced greater difficulty with the less familiar speed and scaling problems. A statistically significant interaction was found between the type of rate and understanding rational numbers as the level of difficulty with the type of rate differed among students with different levels of understanding rational numbers. Finally, the study revealed that the presence of context improved performance on directional problems, reduced it on missing value problems, and had no effect on numerical comparison problems (Heller et al., 2003).

The importance of interaction between intuitive knowledge acquired through natural experience and understanding abstract mathematical concepts was highlighted. It was suggested that the physical similarity between objects is important in eliciting intuitive understanding of relationships (Van de Brink, 1978). This suggestion is based on the assumption that dealing with different objects is easier than dealing with similar ones. For example, mixing two similar objects might push the students to think that there is a one to one correspondence between the two objects not recognizing converting the units of one object to the units of the other. Making the unit characteristics of one object more explicit will increase the recognition of the fact that two objects relate proportionally not one to one.
There are other problem-related factors that affect proportional reasoning. Of these factors are the problem format, the numbers used, and the context. Heller, Ahlgren, Post, Behr, and Lesh, (1989) divides the contextual factors into two categories: (1) problem setting which includes the objects involved in the problem, the variables used to describe these objects, and the measurement units for each variable. The problem is usually described as familiar or unfamiliar based on students’ experience. (2) Type of proportion: direct or inverse.

Lawton (1993) studied the effect of the difference in the contents of the two items in a mixture problem on university students’ proportional reasoning. For this purpose, she developed two mixture problems. One involved mixing two formulas and the other involved mixing a formula and protein. The problem was: 4 is to 6 as 6 is to ----? The study revealed that content had significant effect on students’ performance.

Lawton, also, studied the effect of shape, and unit on students’ proportional reasoning. Three problems were used for this purpose; all of them required solving the above mentioned problem. In the first problem, water was described as rising from 4 to 6 marks when transferred from a wide to a narrow cylinder. Students’ task was to determine the quantity of water in the narrow cylinder given that the quantity in the wide cylinder was 6. In the second, water was described as being transferred from a balloon filled to 4 cubic inches of water to a cylinder. Students’ task was to determine the quantity of water in the cylinder given that the quantity in the balloon was 6. In the third problem, water was described as transferred from 4 melted ice cubes to a cylinder. Students’ task was to determine the quantity of water in the cylinder given that the ice cubes were 6.

The first item in problem 1 differs from that in problem 2 in shape (cylinder versus balloon). The units in problem 3 are clearer than these in problems 1 and 2 as problem 3 involves a discrete quantity (ice cubes) while problems 1 and 2 involve continuous quantities. The study revealed a significant difference between performances on problem 3 and that on the other 2 problems favoring problem 3. No difference was found between performance on problems 1 and 2. Based on these results, Lawton (1993) concluded that (a) shape did not play a role in proportional reasoning, and (b) the clarity of units in the problem plays an important role in proportional reasoning. In interpreting the result, she considered that the ice cubes problem significantly increased “proportional reasoning most likely because the two items in the problem differed both in shape and content (ice versus water) and also because the unit characteristics of one of the items (the ice cubes) were made visually explicit” (p. 464).

Studying the design of problems in Lawton (1993), one can highlight 2 problems: (a) not controlling for units when comparing shapes in problems 1 and 2 as the units in one is cylinder marks and in the other is cubic inch; and (b) not controlling content when testing the effect of unit. The content in problem 1 and 2 was water while in problem 3 it was ice. This has weakened Lawton’s interpretation of some results. Instead of assuring that the clarity of units was the reason for the difference in performance, she added 2 other reasons: shape and content. Since the tested factors in a study are so important in decision making by teachers and curriculum developers, they should be studied more precisely in a dependable way. This is part of what this study provides.

This study aimed at exploring the effect of some contextual factors on proportional reasoning of students from different grade levels. Those factors involved content, shape, unit, and type of quantity. It, also, aimed at exploring strategies used by students to solve proportion problems and whether the type of problem affects the choice of solution strategy. Further, it aimed at comparing the performances of males and females on proportion problems. Moreover, as recommended by previous research (i.e Lawton, 1993) the study tested the possibility of the transfer of proportional reasoning from problems that elicit an intuitive understanding of proportion to problems that do not. More specifically, the study aimed at answering the following questions:

1. Are there statistically significant differences in proportional reasoning of students in grades 7, 9, and 11 due to content, type of quantity, shape, and unit?
2. Are there statistically significant differences in proportional reasoning of students due to grade level?
3. Are there statistically significant differences in proportional reasoning of students due to gender?
4. Do the strategies used in solving proportion problems differ due to content, type of quantity, shape, and unit?
5. Does the type of problem solve first affect the student’s solution of the second problem?

METHODOLOGY

Sample

The sample of the study consisted of 2370 students in grades 7, 9, and 11. All of students were from Abu Dhabi Emirate, the United Arab Emirates (UAE). Schools were selected randomly. Table 1 below shows the breakdown of subjects by grade level and gender.
### Table 1

**Breakdown of Subjects by Grade Level and Gender**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Grades</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>375</td>
<td>390</td>
<td>420</td>
<td>1185</td>
</tr>
<tr>
<td>Females</td>
<td>395</td>
<td>390</td>
<td>400</td>
<td>1185</td>
</tr>
<tr>
<td>Total</td>
<td>770</td>
<td>780</td>
<td>820</td>
<td>2370</td>
</tr>
</tbody>
</table>

### INSTRUMENTS

Five different versions of the proportion problem: 4 is to 6 as 6 is to ---? were used in the study. Each problem consisted of a diagram and accompanying text (see Figure 1 for the diagrams). The problems differed in content, type of quantity, shape, and unit. The problems were developed after a thorough review of the literature and studying problems used in previous studies specially those used in Lawton (1993) and Niaz (1989). After developing the problems, they were evaluated by experts in mathematics education in terms of their suitability for the sample and their ability to test proportional reasoning. Then the problems were evaluated by language experts in terms of their readability. Following is a description of each problem.

**Problem 1, Ice Cubes problem (Figure 1.1):** water was described as being transferred from 4 melted ice cubes to a marked cylinder. Students were asked to predict the number of marks given that the ice cubes were 6.

**Problem 2, Four Balloons problem (Figure 1.2):** water was described as being transferred from 4 balloons to a marked cylinder. Students were asked to predict the number of marks given that the balloons were 6.

**Problem 3, One Balloon problem (Figure 1.3):** water was described as being transferred from a balloon filled to 4 cubic centimetres to a marked cylinder. Students were asked to predict the number of marks given that the balloon was filled to 6 cubic centimetres.

**Problem 4, Unmarked Cylinder problem (Figure 1.4):** water was described as rising from 4 to 6 marks as being transferred from a wide unmarked cylinder filled to 4 cubic centimetres to a narrow marked cylinder. Students were asked to predict the number of marks given that the wide unmarked cylinder was filled to 6 cubic centimetres.

**Problem 5, Marked Cylinder problem (Figure 1.5):** water was described as rising from 4 to 6 marks when transferred from a wide marked cylinder to a narrow marked cylinder. Students were asked to predict the number of marks given that the number of marks on the wide cylinder was 6.

Problems 1 and 2 provide a context to test the effect of content (the first item was ice in problem 1 and water in problem 2) with controlling for shape, units, and type of quantity. Problems 2 and 3 provide a context to test the effect of the type of quantity (the first item involved a discrete quantity in problem 2 and a continuous quantity in problem 3) with controlling shape, unit, and content. Problems 3 and 4 provide a context to test the effect of shape (problem 3 involves a balloon and a cylinder while problem 4 involves cylinders in both positions) with controlling for content, units, and type of quantity. Finally, Problems 4 and 5 provide a context to test the effect of unit (problem 4 involves converting cubic centimetres into marks on a cylinder while problem 4 involves marks in both positions) with controlling for content, shape, and type of quantity.
Figure 1. Proportion problems
Procedures

Have the final version of the problems developed, they were piloted with 90 students (30 from each of the grades 7, 9, and 11) for three purposes: (a) to detect any ambiguities in the problems and make sure that the texts and diagrams are understandable to students, (b) to determine the time needed for solving each problem, and (c) to identify the most difficult problem to be included in stage 2. As a result, it was found that 10 minutes are needed for solving each problem. Also, problem 4 was found to be the most difficult and therefore was chosen to be the problem for stage 2.

Ten schools were randomly selected from Abu Dhabi Emirate, UAE. Since schools in UAE are segregated by gender, five female schools and five male schools were selected. The researcher trained math supervisors to administer the exam. In each section and before distributing the exam, the supervisor urged the students to make all efforts to solve the problem. Also, students were asked to write explanations to their solutions. Then the problems were distributed randomly to students such that each student gets one problem (stage 1). After ten minutes, the exams were collected from them. Then, problem 4 was given to all students (stage 2). Again, students were given 10 minutes to work on the problem.

The same supervisors scored the exams. Quantitative performance on the problems was coded as “1” if correct and “0” if incorrect; females were coded as “0” and males as “1.” Students' strategies in solving the problems were categorized into 4 categories.

a. Cross product strategy if the student used the cross product algorithm.

b. Unit strategy if the student calculated the number of marks for each unit and then multiplied by 6.

c. Additive strategy if the student calculated the difference between 6 and 4 and then added this difference to 6 to obtain 8 as an answer.

d. Undetermined if the student did not show how s/he solved the problem or if s/he used an awkward strategy. This usually happens when the answer is incorrect.

A special form was used to record the results. The form involved student's name, grade, gender, problem number (in stage 1), the score in each stage, and the solution strategy used.

RESULTS

Results are presented in this section according to the five research questions mentioned above.

Research Question 1 stating: “Are there statistically significant differences in proportional reasoning of students in grades 7, 9, and 11 due to content, type of quantities, shape, and units?”

Generally, the results indicated low performance of students on proportion problems. Except for problems 1 and 2, the highest mean on any of the problems and for all participants did not exceed 0.30 (maximum score is 1). For grade 7, mean scores on the 5 problems ranged between 0.1 and 0.25. Mean scores on the 5 problems differed substantially (see table 2). Means on problems 1 and 2 were higher than those on other problems. Problems 4 and 5 seemed to be the most difficult among all problems. This pattern was the same in all grade levels.

Table 2

<table>
<thead>
<tr>
<th>Grade</th>
<th>problem</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1: Ice cubes</td>
<td>154</td>
<td>.36</td>
<td>.48</td>
</tr>
<tr>
<td>2: Four balloons</td>
<td>154</td>
<td>.34</td>
<td>.47</td>
<td></td>
</tr>
<tr>
<td>3: One balloon</td>
<td>154</td>
<td>.19</td>
<td>.40</td>
<td></td>
</tr>
<tr>
<td>4: Unmarked cylinder</td>
<td>154</td>
<td>.10</td>
<td>.33</td>
<td></td>
</tr>
<tr>
<td>5: Marked cylinder</td>
<td>154</td>
<td>.10</td>
<td>.31</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1: Ice cubes</td>
<td>156</td>
<td>.67</td>
<td>.47</td>
</tr>
<tr>
<td>2: Four balloons</td>
<td>156</td>
<td>.58</td>
<td>.5</td>
<td></td>
</tr>
<tr>
<td>3: One balloon</td>
<td>156</td>
<td>.24</td>
<td>.43</td>
<td></td>
</tr>
<tr>
<td>4: Unmarked cylinder</td>
<td>156</td>
<td>.15</td>
<td>.36</td>
<td></td>
</tr>
<tr>
<td>5: Marked cylinder</td>
<td>156</td>
<td>.19</td>
<td>.39</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1: Ice cubes</td>
<td>164</td>
<td>.84</td>
<td>.37</td>
</tr>
<tr>
<td>2: Four balloons</td>
<td>164</td>
<td>.72</td>
<td>.45</td>
<td></td>
</tr>
<tr>
<td>3: One balloon</td>
<td>164</td>
<td>.30</td>
<td>.46</td>
<td></td>
</tr>
<tr>
<td>4: Unmarked cylinder</td>
<td>164</td>
<td>.18</td>
<td>.39</td>
<td></td>
</tr>
<tr>
<td>5: Marked cylinder</td>
<td>164</td>
<td>.19</td>
<td>.39</td>
<td></td>
</tr>
</tbody>
</table>
Analysis of variance (ANOVA) revealed significant differences in mean scores due to the contextual factors (p < .05) in all grade levels (see table 3).

Table 3
ANOVA Summary for Contextual Factors

<table>
<thead>
<tr>
<th>Grade</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Between Groups</td>
<td>9.28</td>
<td>4</td>
<td>2.32</td>
<td>14.24</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>124.63</td>
<td>765</td>
<td>.16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>133.91</td>
<td>769</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Between Groups</td>
<td>37.18</td>
<td>4</td>
<td>9.30</td>
<td>50.13</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>143.69</td>
<td>775</td>
<td>.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>180.87</td>
<td>779</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Between Groups</td>
<td>63.36</td>
<td>4</td>
<td>15.84</td>
<td>92.62</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>139.38</td>
<td>815</td>
<td>.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>202.75</td>
<td>819</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Post Hoc analysis revealed significant differences between each of problems 1 and 2 and all other problems (3, 4, and 5), indicating that these two problems are significantly easier than all others. Also, the analysis revealed no significant differences between problems 1 and 2 nor between any pair of the problems 3, 4, and 5 in any of the grades. Based on these results, question 1 is answered as follows:

1) There is no significant difference in mean scores due to content (Problems 1 and 2).
2) There are significant differences due to the type of quantities (Problems 2 and 3).
3) There is no significant difference due to shape (Problems 3 and 4).

There is no significant difference due to unit (Problems 4 and 5).

II. Research question 2 states: “Are there statistically significant differences in proportional reasoning of students due to grade level?”

Clearly, mean scores on problems 1 and 2 increased with the grade level. The mean on problem 1 was .36 for grade 7, .67 for grade 9, and .84 for grade 11. On problem 2, the mean was .34 for grade 7, .58 for grade 9, and .72 for grade 11. Interestingly, however, mean differences on problems 3, 4, and 5 were much less (see table 2).

To test the significance of mean differences, the analysis of variance was done. The analysis revealed significant differences due to grade levels on problems 1 and 2 (p < .05). However, no significant differences among the grades on problems 3, 4, and 5 at level α = .05 (see table 4 for the summary of analysis). Post Hoc analysis for problems 1 and 2 revealed that on both problems, grade 11 outperformed grade 9 which, in turn, outperformed grade 7.
Research Question 3 stating: “Are there statistically significant differences in proportional reasoning of students due to gender?”

On most of the problems, mean scores of males were higher than those of females in all grade levels (see table 5). ANOVA was used to test the significance of these differences on each problem in all grade levels. ANOVA summary is presented in table 6.

### Table 5

<table>
<thead>
<tr>
<th>Grade</th>
<th>Problem</th>
<th>Gender</th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1: Ice cubes</td>
<td>female</td>
<td>79</td>
<td>.33</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>75</td>
<td>.39</td>
<td>.49</td>
</tr>
<tr>
<td></td>
<td>2: Four balloons</td>
<td>female</td>
<td>79</td>
<td>.34</td>
<td>.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>75</td>
<td>.33</td>
<td>.48</td>
</tr>
<tr>
<td></td>
<td>3: One balloon</td>
<td>female</td>
<td>79</td>
<td>.15</td>
<td>.36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>75</td>
<td>.24</td>
<td>.43</td>
</tr>
<tr>
<td></td>
<td>4: Unmarked cylinder</td>
<td>female</td>
<td>79</td>
<td>.08</td>
<td>.31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>75</td>
<td>.13</td>
<td>.34</td>
</tr>
<tr>
<td></td>
<td>5: Marked cylinder</td>
<td>female</td>
<td>79</td>
<td>.11</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>75</td>
<td>.09</td>
<td>.29</td>
</tr>
<tr>
<td>9</td>
<td>1: Ice cubes</td>
<td>female</td>
<td>78</td>
<td>.63</td>
<td>.49</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>78</td>
<td>.72</td>
<td>.45</td>
</tr>
<tr>
<td></td>
<td>2: Four balloons</td>
<td>female</td>
<td>78</td>
<td>.50</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>78</td>
<td>.67</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td>3: One balloon</td>
<td>female</td>
<td>78</td>
<td>.14</td>
<td>.35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>78</td>
<td>.33</td>
<td>.47</td>
</tr>
<tr>
<td></td>
<td>4: Unmarked cylinder</td>
<td>female</td>
<td>78</td>
<td>.09</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>78</td>
<td>.21</td>
<td>.41</td>
</tr>
<tr>
<td></td>
<td>5: Marked cylinder</td>
<td>female</td>
<td>78</td>
<td>.12</td>
<td>.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>78</td>
<td>.26</td>
<td>.44</td>
</tr>
<tr>
<td>11</td>
<td>1: Ice cubes</td>
<td>female</td>
<td>80</td>
<td>.84</td>
<td>.37</td>
</tr>
<tr>
<td></td>
<td></td>
<td>male</td>
<td>84</td>
<td>.85</td>
<td>.36</td>
</tr>
</tbody>
</table>
ANOVA revealed no significant differences on any of the problems due to gender in grades 7. However, significant differences existed on problems (2 through 5) in both grades 9 and 11 ($p < .05$) favouring males indicating the superiority of males over females in solving difficult proportion problems (Table 6).

Table 6

<table>
<thead>
<tr>
<th>Grade</th>
<th>Problem</th>
<th>Source</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1</td>
<td>Between Groups</td>
<td>.127</td>
<td>1</td>
<td>.127</td>
<td>.55</td>
<td>.460</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>35.23</td>
<td>152</td>
<td>.232</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Between Groups</td>
<td>.003</td>
<td>1</td>
<td>.003</td>
<td>.01</td>
<td>.913</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>34.44</td>
<td>152</td>
<td>.227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Between Groups</td>
<td>.30</td>
<td>1</td>
<td>.299</td>
<td>1.90</td>
<td>.170</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>23.86</td>
<td>152</td>
<td>.157</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Between Groups</td>
<td>.13</td>
<td>1</td>
<td>.127</td>
<td>1.19</td>
<td>.277</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>16.21</td>
<td>152</td>
<td>.107</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Between Groups</td>
<td>.02</td>
<td>1</td>
<td>.016</td>
<td>.17</td>
<td>.678</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>14.32</td>
<td>152</td>
<td>.094</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>1</td>
<td>Between Groups</td>
<td>.31</td>
<td>1</td>
<td>.314</td>
<td>1.42</td>
<td>.235</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>34.01</td>
<td>154</td>
<td>.221</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Between Groups</td>
<td>1.08</td>
<td>1</td>
<td>1.08</td>
<td>4.53</td>
<td>.035</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>36.83</td>
<td>154</td>
<td>.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Between Groups</td>
<td>1.44</td>
<td>1</td>
<td>1.44</td>
<td>8.29</td>
<td>.005</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>26.78</td>
<td>154</td>
<td>.17</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Between Groups</td>
<td>.52</td>
<td>1</td>
<td>.52</td>
<td>4.19</td>
<td>.042</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>19.09</td>
<td>154</td>
<td>.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Between Groups</td>
<td>.78</td>
<td>1</td>
<td>.78</td>
<td>5.23</td>
<td>.024</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>22.83</td>
<td>154</td>
<td>.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>1</td>
<td>Between Groups</td>
<td>.002</td>
<td>1</td>
<td>.002</td>
<td>.018</td>
<td>.893</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>21.88</td>
<td>162</td>
<td>.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>Between Groups</td>
<td>1.79</td>
<td>1</td>
<td>1.79</td>
<td>9.26</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>31.31</td>
<td>162</td>
<td>.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>Between Groups</td>
<td>1.0</td>
<td>1</td>
<td>1.0</td>
<td>4.78</td>
<td>.030</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>33.76</td>
<td>162</td>
<td>.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>Between Groups</td>
<td>1.82</td>
<td>1</td>
<td>1.82</td>
<td>12.99</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>22.69</td>
<td>162</td>
<td>.14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>Between Groups</td>
<td>2.50</td>
<td>1</td>
<td>2.50</td>
<td>17.89</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Within Groups</td>
<td>22.64</td>
<td>162</td>
<td>.14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
IV. Research Question 4 stating: “Do the strategies used in solving proportion problems differ due to content, type of quantities, shape, and unit?”

Percentages of strategies used in solving problems are shown in Table 7. It can be noted that the unit strategy was used most frequently with problems 1 and 2. On the other hand, additive strategy was used least frequently with these two problems. The percentages of unit strategy increased in problems 1 and 2 and decreased in all other problems. The percentages of additive strategy, however, decreased in problems 1 and 2 and increased in other problems. Cross multiplication strategy, however, was less variant among the five problems.

Table 7
Percentages of Strategies Used in Solving Each Problem

<table>
<thead>
<tr>
<th>Problem</th>
<th>cross multiplication</th>
<th>Unit</th>
<th>additive</th>
<th>others</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.9</td>
<td>40.7</td>
<td>23</td>
<td>26.4</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>30.6</td>
<td>22.2</td>
<td>39.2</td>
</tr>
<tr>
<td>3</td>
<td>4.6</td>
<td>9.9</td>
<td>45.8</td>
<td>39.7</td>
</tr>
<tr>
<td>4</td>
<td>6.3</td>
<td>3.6</td>
<td>52.7</td>
<td>37.3</td>
</tr>
<tr>
<td>5</td>
<td>6.8</td>
<td>4.9</td>
<td>54.9</td>
<td>33.5</td>
</tr>
</tbody>
</table>

V. Research Question 5 stating: “Does the type of problem solved first affect the student's solution of the second problem?”

Means and standard deviations were calculated for each group in each grade. A summary of the results is presented in Table 8.

Table 8
Mean Scores and Standard Deviations in Stage 2

<table>
<thead>
<tr>
<th>Grade</th>
<th>Problem solved in stage 1</th>
<th>N</th>
<th>M (Stage 2)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>1: Ice cubes</td>
<td>154</td>
<td>.17</td>
<td>.376</td>
</tr>
<tr>
<td></td>
<td>2: Four balloons</td>
<td>154</td>
<td>.13</td>
<td>.337</td>
</tr>
<tr>
<td></td>
<td>3: One balloon</td>
<td>154</td>
<td>.12</td>
<td>.322</td>
</tr>
<tr>
<td></td>
<td>4: Unmarked cylinder</td>
<td>154</td>
<td>.09</td>
<td>.288</td>
</tr>
<tr>
<td></td>
<td>5: Marked cylinder</td>
<td>154</td>
<td>.08</td>
<td>.269</td>
</tr>
<tr>
<td>9</td>
<td>1: Ice cubes</td>
<td>156</td>
<td>.30</td>
<td>.460</td>
</tr>
<tr>
<td></td>
<td>2: Four balloons</td>
<td>156</td>
<td>.26</td>
<td>.442</td>
</tr>
<tr>
<td></td>
<td>3: One balloon</td>
<td>156</td>
<td>.15</td>
<td>.356</td>
</tr>
<tr>
<td></td>
<td>4: Unmarked cylinder</td>
<td>156</td>
<td>.13</td>
<td>.342</td>
</tr>
<tr>
<td></td>
<td>5: Marked cylinder</td>
<td>156</td>
<td>.14</td>
<td>.351</td>
</tr>
<tr>
<td>11</td>
<td>1: Ice cubes</td>
<td>164</td>
<td>.49</td>
<td>.501</td>
</tr>
<tr>
<td></td>
<td>2: Four balloons</td>
<td>164</td>
<td>.41</td>
<td>.494</td>
</tr>
<tr>
<td></td>
<td>3: One balloon</td>
<td>164</td>
<td>.29</td>
<td>.454</td>
</tr>
<tr>
<td></td>
<td>4: Unmarked cylinder</td>
<td>164</td>
<td>.22</td>
<td>.415</td>
</tr>
<tr>
<td></td>
<td>5: Marked cylinder</td>
<td>164</td>
<td>.21</td>
<td>.411</td>
</tr>
</tbody>
</table>

Table 8 clearly shows that students who worked on problem 1 or 2 in stage 1 averaged more on problem 4 in stage 2 than those who worked on other problems in stage 1. To test the significance of the differences in groups’ means, ANOVA was used. The results of the analysis are presented in Table 9.
Table 9
ANOVA Results for Stage 2

<table>
<thead>
<tr>
<th>Grade</th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Groups</td>
<td>.779</td>
<td>4</td>
<td>.195</td>
<td>1.89</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>78.701</td>
<td>765</td>
<td>.103</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>79.481</td>
<td>769</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Between Groups</td>
<td>3.851</td>
<td>4</td>
<td>.963</td>
<td>6.23</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>119.744</td>
<td>775</td>
<td>.155</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>123.595</td>
<td>779</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Between Groups</td>
<td>10.105</td>
<td>4</td>
<td>2.526</td>
<td>12.11</td>
</tr>
<tr>
<td></td>
<td>Within Groups</td>
<td>169.957</td>
<td>815</td>
<td>.209</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>180.062</td>
<td>819</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The analysis of variance revealed significant differences among groups in grades 9 and 11. In grade 7, however, even though the means were higher for groups 1 and 2 but the differences were not significant. Post Hoc analysis revealed that group 1 significantly outperformed groups 3, 4, and 5 in both grade 9 and grade 11. Also, group 2 significantly outperformed groups 4 and 5 in both grade 9 and grade 11.

DISCUSSION

The first finding this study revealed was the low level of student’s performance in solving proportion problems even though all subjects have formally studied ratio and proportions. Subjects’ correct answers on problems 1 (Ice Cubes) ranged between 36% for grade 7 and 84% for grade 11. On problem 2, the correct answers ranged between 34% for grade 7 and 72% for 11. But the correct answers on other problems were concerning. For example, only 10% of 7th graders, 15% of 9th graders and 18% of 11th graders answered problem 4 (Unmarked Cylinder) correctly in stage 1. Similar results were found by previous studies (Kolodity, 1977; Lawson & Renner, 1975).

It is clear that the contexts for problems 1 and 2 were the reason behind the high percent of correct answers. Both problems involved discrete quantities while all other problems involved continuous quantities. As the stage of abstract thinking is completely free of context (Driver, 1978), these results indicate general weakness of students’ abstract thinking. These results also reflect weakness of the mathematics curriculum and teaching methods because learning experiences play an important role in developing students’ thinking (Ann-Kim, 2003; Spinillo and Bryant, 1999).

As for the factors affecting proportional reasoning, content was shown not to play a role in proportional reasoning. The difference in mean scores on problems 1 and 2 was not significant. This result differed from what Lawton (1993) arrived at as she concluded that content had a significant effect on proportional reasoning. However, it should be noted that in Lawton’s (1993) study, mixture problems were used to test the effect of content. The type of quantity, however, was shown to have a significant effect on students’ proportional reasoning. Problem 2 (Four balloons problem) received significantly higher scores than problem 3 (One balloon problem), clearly, because of the explicitness of units in discrete quantities. In problem 2 where 4 balloons are poured in a marked cylinder, it is easy for the student to estimate the marks each balloon makes (1.5) which facilitates the calculation of marks made by 6 similar balloons. While problem 3, involving a continuous quantity, does not provide such opportunity. The unit strategy was used much more frequently in problem 2 than in problem 3 (30.6% versus 9.9%) which gives a strong support to this interpretation. So, it can be concluded that problems containing discrete quantities are easier for students than those containing continuous quantities.

Shape was shown not to have effect on proportional reasoning. Answers on problems 3 (One Balloon problem) and 4 (Unmarked Cylinder problem) did not differ significantly. This result is in agreement with those of Lawton (1993). However, Lawton’s study did not control for units as this study did. Finally, the similarity of units in the problem was shown not to have effect on proportional reasoning as mean scores on problems 4 and 5 (Marked Cylinder problem) did not differ significantly. This indicates that the presence of continuous quantities is a challenge to students regardless of the units.

As for the difference in performance due to grade level, the study revealed that grade 11 students outperformed those in grade 9 who, in turn, outperformed those in grade 7 only on problems 1 and 2, the easiest problems. There were no significant differences among the grades on problems 3, 4, and 5 at level α = .05 (see table 4 for the summary of analysis). These results are so interesting and concerning. The mean scores on the
understanding of proportional reasoning. This requires avoiding the teaching of mechanical use of the cross product algorithm. Students need to understand the relationships involved in the problem first and then think proportional reasoning earlier in school.

In the light of the results revealed by this study, there is a great necessity to help students develop proportional reasoning earlier in school. This requires avoiding the teaching of mechanical use of the cross product algorithm. Students need to understand the relationships involved in the problem first and then think about how to solve for the unknown using their own strategies. At that time, it is appropriate to introduce the cross product algorithm as a shortcut (Van De Walle, 2001). Since the type of quantities used in the problem affects students' performance on it, it is preferable that instruction starts with using discrete quantities and then moves to continuous quantities with focus on the quantitative relations involved in the problems. Further, students should be helped to see the ratio as a comparison between two quantities related multiplicatively. This, of course, will not happen without exposing students to plenty of varied experiences involving proportional relationships in familiar contexts. Activities such as estimation games, for example, would provide an opportunity for deepening students' thinking about mathematical relationships (Ann-Kim, 2003). Generally, reasoning and problem solving should be the main aspects of the mathematics classroom (NCTM, 2000).

From a research point of view, this study can be a basis for future research focusing on learning transfer. An experience with one problem helped students from grades 9 and 11 in solving a more complex problem. Future research might examine how this transfer of reasoning can be increased. Research can also examine how this result can be achieved with lower grades.
REFERENCES


TEACHERS’ PERCEPTIONS OF THEIR PRINCIPALS’ INTERPERSONAL BEHAVIOUR AND THEIR ATTITUDES TO THE USE OF ICT IN TEACHING AND LEARNING IN PRIMARY SCHOOLS IN SINGAPORE

Agnes Ang and Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

Research on perceptions of school environments in recent years reveals that the principal’s effect on the effectiveness of technology integration and overall school environment is significant. This study first reports the validation of both the Principal’s Interaction Questionnaire (PIQ) and the Computer Attitude Scale (CAS) questionnaire in Singapore Primary schools. The second objective was to investigate associations between teachers’ perceptions of the principal’s interpersonal behaviour and their attitudes to the use of information and communication technology in teaching and learning in the Singapore Primary school environment. The study involved 476 teachers in seven government and government-aided Singapore Primary schools who responded to the 48-item PIQ and the 32-item CAS. This is a first ever study in Singapore using the PIQ instrument which assesses eight scales of teacher perceptions of the school environment. Previous research had confirmed the reliability and validity of the PIQ for use with secondary school teachers in Australia. Statistical analysis done in this research has provided further evidence on the validation of the PIQ for primary school teachers in Singapore. The CAS was also shown to be reliable and valid. The study showed that the dimensions of the PIQ were found to be statistically significantly associated with teacher attitude scores.

INTRODUCTION

Integrating technology into instruction has been considered a key issue in current education reform in many countries (Koul & Fisher, 2005; Lim & Hang, 2003; National Research Council, 1996; van Braak, 2001; Wu, Hsu, & Hwang, 2007). With the birth of the information age, Singapore’s competitiveness is dependent on its people’s ability to exploit information and communication technology. The government of Singapore realized that a carefully planned program must start in the public schools to prepare our youth for the workplace of the future. Teachers need to use ICT to make learning interesting and stimulating for our students and nurture their creative and thinking skills. With that in mind, IT2000 plan was announced in 1992 which led to the development of Masterplans (MP1 and MP2) for IT in Education to support the pervasive use of IT in Singapore schools anywhere anytime (MOE Overview of MasterplanII for ICT in Education, updated 30 November 2006).

Despite the efforts made by governments in many countries, including Singapore, such as investment in resources, hardware and software introduced into the classrooms, and training provided for teachers, few teachers perceive the computer as an indispensable part of their teaching and computers in education have not yet met the expectations of policy makers and researchers (van Braak, 2001). Teachers’ attitudes toward computers are well documented as significant determinants of behaviour that could influence teachers’ decision to use computers in instruction (Fabry & Higgs, 1997; Francis, Katz, & Jones, 2000; Lawton & Gierschner, 1982; Troutman, 1991). The relation between computer attitudes and computer experience is described extensively in research literature (Gardner, Discenza, & Dukes, 1993; Kay, 1989; Loyd & Gressard, 1984; Woodrow, 1991). Teachers’ computer experience has been shown to have a positive influence on computer confidence and computer attitudes (Levine & Donitsa-Schmidt, 1997) and their perception of the usefulness of technology and how easily it can be used facilitates their computer use for instruction (Knezek, Christensen & Rice, 1996; Lam, 2000). While Cuban’s (1996) and Feiman-Nemser and Remillard’s (1996) studies on teacher technology education showed limited impact on how teachers thought about and implemented technology-supported teaching, whereas Keirns’ (1992) claimed that attending technology courses can help teachers develop a positive attitude toward technology and encourage them to “think about the integration of computers into their personal teaching situations” (p. 34).

The primary motivation for using technologies in education is the belief that they will support superior forms of learning, labeled constructivist learning (Means, Blando, Olson, Middleton, Morocco, & Zofass, 1993). According to Porras and Silvers (1991), for teachers to shift from a traditional practice teaching in a teacher-centered paradigm to student-centered paradigm requires a change in their beliefs which in turn creates different behaviours. Even among exemplary teachers, barriers to technology integration are reported to exist (Becker, 1994).
While it is the teacher’s decision to use the computers in the classroom in a constructivist manner, it is the principal’s belief in the values of technology that manifests itself in his/her expectations of teachers’ use to enhance learning and his/her constant encouragement that provide a supportive and conducive environment for the use of technology in the whole school system (Bailey & Lumley, 1997; Hughes & Zachariah, 2001; Schiller, 2003). Czerniak, Haney, Lumpe, and Beck (1999) found that although many teachers share beliefs that ICT could promote learning and that the use of technology is desirable, they are reluctant to use ICT because of insufficient support and resources provided by the school. Unless the principals value the beliefs, constraints, and capitalize on the unique learning opportunities of their teachers, they are not likely to enlist support of organizational changes (Bailey, 1997). Successful leaders will have different leadership styles, but they will need to believe in its value and have a vision of learning transformed by ICT (Evans, 2002; Sheppard, 2000; Walsh, 2000; Yee, 2000). Principals who shape culture have a clear and focused sense of mission and values and develop a vision of what the school should be (Deal & Peterson, 1990; Leithwood & Jantzi, 1990). As leaders, principals “communicate their vision by how they spend their time, what they talk about, what problems they solve first, and what they get excited about. In every act, leaders reinforce the values they hold and the vision they hope to achieve” (NCREL, 2000, p. 5). This in turn may become a barrier to the teachers’ perceived needs to effectively integrate technology into instruction as teachers are perceptive of their principal’s beliefs through their behaviour and individual school’s characteristics reflect those of its principal when incorporating information technology (Wiggins, 1970).

Sweetland and Hoy (2000) claimed that school climate which has a strong teacher empowerment is crucial for school effectiveness, including success in ICT implementation in the school and thus student achievement. Hughes (1991) emphasized that every school has a pervasive climate which has an influence on the behaviour of teachers and students to succeed in teaching and learning. The assertion is that if teachers have a supportive and conducive working environment then better student achievement will result. Similarly, Purkey and Smith (1983) concluded that research is persuasive in suggesting that student performance is strongly affected by school culture, which is in turn related to the school environment.

Cresswell and Fisher (1996) noted that there were significant relationships between school environment and principals’ interpersonal behaviour. Cresswell and Fisher (1998) found a positive relationship existed between the principal’s leadership behaviour and the teachers’ perceptions of the school as being innovative and empowering them in their working environments. In the assessment of their environment, teachers were least affected by their principals’ understanding and helpful behaviour. Teachers were most affected by the principal’s leadership behaviour and whether they were granted independence to carry out their tasks. Principals with critical, admonishing, or uncertain interactive styles negatively affected their teachers. All this implies that it is essential to look at the teachers’ perspectives of the role the principal undertakes to facilitate the change process for effective technology integration.

**BACKGROUND**

A series of studies have looked at teachers’ attitudes toward computer technology. Studies to date have focused mainly on investigating (a) how technology impacts the teachers’ perceptions and attitudes about their role in the classroom (Chin & Hortin, 1994; Dupagne & Kendl, 1992); (b) the relationship between self-efficacy beliefs and actual computer use in the classroom (Marcinkiewicz & Regstad, 1996; Ross, 1994); (c) levels of computer anxiety among teachers (Bradley & Russell, 1997; Gressard & Loyd, 1985); and (d) the relationship between teachers’ personal teaching philosophy and computer technology use (Briscoe, 1991; Rich, 1990; Sparks, 1988). Missing from the literature, however, are investigations, which apply broad motivational frameworks for examining the association between teachers’ perception of the principal’s interpersonal behaviour that may have impact on the teachers’ attitude and beliefs about computer technology use in teaching and learning.

For years, computer technologies are often used peripheral to learning and seen as an “add-on activity or simply technological versions of the workbook approaches that are already prevalent…” (Hadley & Sheingold, 1993, p. 265). For teachers to have a positive attitude towards the use of computers, they need to be willing to take risk, to spend time, money and effort to explore and learn more about the possible uses of computers in teaching and learning. Like all educational change, integrating ICT in the classroom is a complex and dynamic process involving interactions among human, technology and organizational structures (Cohen, 1987; Kerr, 1996). The challenge involved is not simply a case of technological adoption; it involves transforming of teachers’ beliefs and behavioural patterns, changes in the school’s culture, improvement of student performance and adaptation to the environmental changes.

Over the last three decades school environment has consistently been identified as one of the main factors that affect the effectiveness of a school (Creemers, Peters, & Reynolds, 1989) and confirmed by the findings of various studies (Atwool, 1999; Fisher & Fraser, 1990; Freiberg, 1998). School environment plays a significant role in creating a school’s effectiveness, including success in ICT implementation in the school and in turn provides students with better learning (Fisher & Fraser, 1990). With better teacher affiliation, resource support,
academic expectation, and institutional integrity, school environment promotes better student achievement (Hoy & Hannum, 1997). Transforming industrial age schools into information age schools will not happen without active leadership by the school principal (Kozloski, 2006; MacNeil & Delafield, 1998; Wilmore & Betz, 2000) whose actions in the schools serve to legitimate if a change is to be taken seriously (Fullan, 1991).

The absence of a systematic policy and proven planning strategy can hamper teachers’ efforts to incorporate computers into the classroom (Cuban, 2000; Morton, 1996). In a critical evaluation of technology adoption in two “high-tech” schools, Cuban, Kirkpatrick, & Peck (2001) warned that “…the prevailing assumptions guiding policy on new technologies in schools are deeply flawed and in need of re-assessment” (p. 830). Direction is needed from the research community on how schools can develop curricular plans and policies that are relevant and sensitive to issues related to computer integration.

The role of school administration extends beyond policy to include leadership within the school. Both Hadley and Sheingold (1993) and Marcinkiewicz (1996) suggested the need for a perception within the teachers’ professional environment that computer integration is an expected and necessary component of the job. This perception can be established through modeling the use of computers by the principal, heads of departments, colleagues, students and the larger professional community (Coley, Cradler, & Engel, 1997; Hannay & Ross, 1997; Wiebe, 1999).

Glathorn (1997) asserted that there was abundant evidence that the principal plays a key role in determining the overall effectiveness of the school and identified principal “leadership” as the process of enabling teachers to achieve goals. Wilmore and Betz (2000) maintained that the principal’s role is an important component to the success of technology integration and warned, “that information technology will only be successfully implemented in schools if the principal actively supports it, learns as well, provides adequate professional development and supports his/her staff in the process of change” (p. 15). Researchers agreed that the concept of leadership in ICT integration involves exerting social influences on their people in an attempt to impact their beliefs, values and actions so as to achieve desired outcomes (Flanagan & Jacobsen, 2003; Gardner, 2000; Leithwood & Duke, 1999; Yukl, 1994).

Therefore, this study is one of the first to examine the impact of the principal’s leadership on teachers’ attitudes toward the effective implementation of ICT in schools.

The Principal Interaction Questionnaire (PIQ)

Researchers in The Netherlands (Wubbels, Créton & Hooymayers, 1985) investigated teacher interpersonal behaviour in classrooms from a systems perspective, adopting a theory on communication processes developed by Watzlawick, Beavin, and Jackson (1967). Within the systems perspective on communication, it is assumed that the behaviours of participants influence each other mutually. The behaviour of the teacher is influenced by the behaviour of the students and in turn influences student behaviour. Circular communication processes develop which not only consist of behaviour, but determine behaviour as well. With the systems perspective in mind, Wubbels, Creton and Hooymayers (1985) developed a model to map the interpersonal behaviour of teachers and their students extrapolated from the work of Leary (1957). In the adaptation of the Leary model, teacher behaviour is mapped with a Proximity dimension (Cooperation, C - Opposition, O) and an Influence dimension (Dominance, D, - Submission, S) to form eight sectors, each describing different behaviour aspects (see Figure 1). They developed the Questionnaire on Teacher Interaction (QTI) based on this model. The QTI is composed of eight scales corresponding to the eight sectors depicted in Figure 1.
In Israel, Kremer-Hayon & Wubbels (1993) investigated principals’ leadership style with the teaching staff in the school environment and developed the Questionnaire on Principal Interaction (QPI) from the QTI with the assumption that the theory on communication processes developed by Watzlawick, Beavin, and Jackson (1967) also could hold true for measuring the principal’s interpersonal style with staff. The QPI was developed from the translated version of the original Dutch and American QTI versions to give a 62-item questionnaire QPI. In 1996, a new shorter version of the Principal Interaction Questionnaire (PIQ) was developed from the 48-item version of the QTI in Australia (Fisher and Cresswell, 1996). Table 1 presents a description of each of the scales of the PIQ together with a sample item.

The information obtainable by means of the PIQ includes perceptions of the behaviour of the principal towards the teachers in a school, and reflects relatively stable patterns of behaviour over a considerable period. It can be used to obtain the perceptions of interpersonal behaviour of either the teachers or the principals. When the PIQ is administered to both teachers and principals, information is provided about the perceptions of principals and the perceptions of their teachers of the principal-teacher interactions occurring in the school (Fisher & Cresswell, 1998). It was decided to use the PIQ for the first time in Singapore in this study.

Figure 1. The Model for Teacher Interpersonal Behaviour. (Wubbels & Levy, 1993).
Table 1
*Description and Example of Items for Each Scale in the PIQ*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directive (DC)</td>
<td>Extent to which principal provides direction and leadership to the teachers and school at large and holds teachers attention.</td>
<td>This principal gives clear directions.</td>
</tr>
<tr>
<td>Encouraging (CD)</td>
<td>Extent to which the principal is friendly and helpful towards teachers</td>
<td>This principal takes a personal interest in teachers.</td>
</tr>
<tr>
<td>Understanding (CS)</td>
<td>Extent to which principal shows understanding and care towards teachers</td>
<td>This principal is understanding when staff have problems.</td>
</tr>
<tr>
<td>Giving Independence (SC)</td>
<td>Extent to which the teachers are given opportunities to assume responsibilities for their own activities.</td>
<td>This principal gives teachers the opportunity to develop their own courses.</td>
</tr>
<tr>
<td>Uncertain (SO)</td>
<td>Extent to which principal exhibits his/her uncertainty.</td>
<td>This principal acts as if he/she does not know what to do.</td>
</tr>
<tr>
<td>Disapproving (OS)</td>
<td>Extent to which principal shows unhappiness/dissatisfaction with the teachers.</td>
<td>This principal thinks that teachers at this school can’t do things very well.</td>
</tr>
<tr>
<td>Aggressive (OD)</td>
<td>Extent to which the principal shows anger/temper and is impatient in the school.</td>
<td>This principal is impatient with teachers at this school.</td>
</tr>
<tr>
<td>Strict/Inflexible (DO)</td>
<td>Extent to which the principal is strict with demands of the teachers.</td>
<td>This principal keeps a tight rein on teachers’ activities at school.</td>
</tr>
</tbody>
</table>

**Attitude scales**

In several studies, attitude scales have been developed to measure attitudes toward the social issues to computer use, computer confidence, computer anxiety, attitude towards learning about computers (Delcourt & Kinzie, 1993; Loyd & Gressard, 1984b, 1985, 1986). The original Computer Attitude Scale was developed for use with teachers to measure both affective and evaluative aspects of attitudes toward the use of computers in instruction (Gressard & Loyd, 1985) and was confirmed to be a convenient, reliable, and valid measure of computer attitudes. Gressard and Loyd (1985) found that the perceived relevance of computers can influence attitudes towards computers and the amount of confidence a teacher possesses in using computers may influence his or her implementation in the classroom. By 1986, Gressard and Loyd reported that elementary school teachers who had received computer training were significantly less anxious and more confident about computer use after training than before. Results of many other studies have shown that training has a positive impact on some, if not all, aspects of subject’s self-perception of knowledge, confidence, and attitudes toward computers (Arnez & Lee, 1990; Chen, 1986; Fann, Lynch & Maurranka, 1989; Green & Kluever, 1993). Loyd and Loyd (1989) reported that computer experience has been found to be positively related to attitudes toward, and interest in, the use of computers.

Based on computer attitude scales derived from these studies, particularly the ones from Loyd and Gressard (1984b, 1985, 1986), the Computer Attitudinal Scale was adapted. The Computer Attitude Scale (CAS) included the five subscales of attitude to measure the teachers’ Computer Anxiety, Perceived Competence in Computer Use, Perceived Confidence in Computer Use, Attitude to ICT training, Perceived Relevance/Usefulness of computers in teaching and learning. The CAS was used in this study to assess teachers’ attitude and beliefs about computer technology use in teaching and learning in the primary school environment.

**METHOD**

Given the importance of school environment, principal’s interpersonal behaviour with the staff, the teachers’ attitude toward computer use and effect of principals’ in facilitating technology implementation in the school, this study seeks to explore the interactions among principal and teachers in the school that affect teachers’ attitudes and use of information technology in the classrooms in Singapore.
As the PIQ had not been used in primary schools, in general and in Singapore primary schools in particular, before this study, the validation of this questionnaire in Singapore primary schools formed the focus of the first research question.

1. Is the PIQ a valid and reliable instrument for use in Singapore primary schools?

   As previously mentioned, prior research has indicated a link between the principal-teacher interpersonal behaviour and the teachers’ attitude and beliefs about computer technology use for instructional purposes in the schools. It is therefore timely to examine the effect of teachers’ perceptions of principal-teacher interpersonal behaviour on the teachers’ use of computer technology in the school environment. This provided the focus for the second research question.

2. What associations exist between teachers’ perception of principal-teacher interpersonal behaviour and their attitudes and beliefs in the use of ICT in teaching and learning?

   A number of government and government-aided schools in Singapore were invited to participate in this study. The final sample comprised 476 teachers from seven government and government-aided primary schools in Singapore. Each teacher responded to a paper version of the combined PIQ and CAS questionnaires administered anonymously in one sitting.

   In keeping with previous research studies, the reliability and validity of the PIQ were investigated by determining the scale’s internal consistency, Cronbach alpha coefficient and its ability to distinguish between the perceptions of teachers in different schools. The correlation of each of the PIQ’s eight scales with the other scales was also calculated to confirm the circumplex nature of the PIQ.

   The teachers’ attitudes to use of computer technology in teaching and learning were measured using the CAS. This scale adapted from Loyd and Gressard (1984b, 1985, 1986), contains five subscales each with six to seven items (see Table 3). The five subscales are Computer Anxiety, Perceived Confidence in ICT Use, Perceived Competency in ICT Use, Attitude to ICT Training and Perceived Relevance of ICT Use in Teaching and Learning.

   The associations between teachers’ perceptions of principal-teacher interpersonal behaviour in the school and teachers’ attitudes towards computer technology use were investigated by analyzing the data using simple and multiple correlations. The simple correlation (r) describes the bivariate association between a selected outcome and each scale of the instrument, the PIQ in this instance. The multiple correlation, as expressed by the standardised regression weight (beta) describes the multivariate association between an outcome and a particular scale of the PIQ when all other scales are controlled.

RESULTS

Validation of the PIQ in Singapore primary schools

The Cronbach (1951) alpha reliability coefficient was used to determine the degree to which items in the same scale measure the same aspect of principal’s interpersonal behaviour, and each scale’s ability to differentiate between schools was investigated using ANOVA and the statistic $\eta^2$, with school membership as the main effect and the results are shown in Table 2. The reliability measures for each scale on the PIQ ranged from 0.78 to 0.93 attesting to the PIQ’s reliability. The $\eta^2$ values were significant for all scales and the proportion of variance that could be attributed to school membership ranged from 8 to 34 percent.
Table 2
Scale Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate Between Schools (ANOVA results) for the PIQ

<table>
<thead>
<tr>
<th>Scale</th>
<th>Alpha Reliability</th>
<th>ANOVA (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directive</td>
<td>0.88</td>
<td>0.17***</td>
</tr>
<tr>
<td>Encouraging</td>
<td>0.86</td>
<td>0.17***</td>
</tr>
<tr>
<td>Understanding</td>
<td>0.93</td>
<td>0.28***</td>
</tr>
<tr>
<td>Giving Independence</td>
<td>0.81</td>
<td>0.12***</td>
</tr>
<tr>
<td>Uncertain</td>
<td>0.81</td>
<td>0.08***</td>
</tr>
<tr>
<td>Disapproving</td>
<td>0.91</td>
<td>0.21***</td>
</tr>
<tr>
<td>Aggressive</td>
<td>0.91</td>
<td>0.34***</td>
</tr>
<tr>
<td>Strict/Inflexible</td>
<td>0.78</td>
<td>0.23***</td>
</tr>
</tbody>
</table>

*** p<0.001
The sample consisted of 476 teachers in 7 schools
The eta² statistic (which is the ratio of ‘between’ to ‘total’ sums of squares) represents the proportion of variance explained by school membership

The PIQ is based on a two-dimensional circumplex model for interpersonal behaviour. It assumes that each scale correlates more highly with the scales that are adjacent to it. As you move away from any given scale the correlations decrease until you reach the opposing scale, where the correlation is the most negative; i.e., the most unlike is the scale opposite. Table 3 reports inter-scale correlations from this study as another measure of the validity of the circumplex model for interpersonal teacher behaviour. The data from this study generally support the circumplex nature of the PIQ.

Table 3
Scale Intercorrelations for the PIQ

<table>
<thead>
<tr>
<th>PIQ Scales</th>
<th>Dir DC</th>
<th>Enc CD</th>
<th>Und CS</th>
<th>GI SC</th>
<th>Unc SO</th>
<th>Dis OS</th>
<th>Agg OD</th>
<th>Str DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directive</td>
<td>0.79**</td>
<td>.77**</td>
<td>.68**</td>
<td>– .69**</td>
<td>– .63**</td>
<td>– .58**</td>
<td>– .43**</td>
<td></td>
</tr>
<tr>
<td>Encouraging</td>
<td>.84**</td>
<td>.79**</td>
<td>– .55**</td>
<td>– .70**</td>
<td>– .67**</td>
<td>– .56**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td>.77**</td>
<td>– .60**</td>
<td>– .80**</td>
<td>– .82**</td>
<td>– .65**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Giving Indep.</td>
<td>– .51**</td>
<td>– .68**</td>
<td>– .63**</td>
<td>– .55**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td>.66**</td>
<td>.60**</td>
<td>.46**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disapproving</td>
<td>.85**</td>
<td>.79**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggressive</td>
<td>.73**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p<0.01
The sample consisted of 476 teachers in 7 schools

The Cronbach alpha coefficients obtained for the PIQ, the ANOVA results and the confirmation of the circumplex nature of the PIQ, based on the data collected for this study, attest to the instrument’s reliability and validity for use in research in Singapore primary schools environment.
Validation of the CAS

The alpha reliability coefficient was again used as the index of scale internal consistency for the CAS. As shown here in Table 4, the alpha reliability coefficient as the index of scale internal consistency ranged from 0.57 to 0.81 with a mean value of 0.71, suggesting that all scales of the Computer Attitude Scales possess satisfactory internal consistency (Nunnally, 1967). While the highest alpha reliability was obtained for the Computer Anxiety Scale, the lowest was obtained for the Perceived Relevance in ICT use for teaching and learning scale. Some caution needs to be taken when interpreting findings associated with the Perceived Relevance in ICT use for teaching and learning scale because of its lower alpha coefficients.

Table 4
Scale Mean, Standard Deviation and the Internal Consistency (Cronbach Alpha Reliability) of the CAS

<table>
<thead>
<tr>
<th>Computer Attitude Scale</th>
<th>No. of Items</th>
<th>Scale Mean*</th>
<th>Standard Deviation</th>
<th>Alpha Reliability (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Anxiety</td>
<td>6</td>
<td>1.84</td>
<td>0.58</td>
<td>0.81</td>
</tr>
<tr>
<td>Perceived Confidence in ICT use</td>
<td>6</td>
<td>3.03</td>
<td>0.44</td>
<td>0.70</td>
</tr>
<tr>
<td>Perceived Competency in ICT use</td>
<td>6</td>
<td>3.08</td>
<td>0.47</td>
<td>0.68</td>
</tr>
<tr>
<td>Attitude to ICT Training</td>
<td>7</td>
<td>3.23</td>
<td>0.50</td>
<td>0.79</td>
</tr>
<tr>
<td>Perceived Relevance in ICT use for Teaching and learning</td>
<td>7</td>
<td>3.28</td>
<td>0.38</td>
<td>0.57</td>
</tr>
</tbody>
</table>

* Range of 1 to 4
1=Strongly Disagree, 2 = Slightly Disagree, 3 = Slightly Agree and 4 = Strongly Agree

The sample consisted of 476 teachers in 7 schools

The mean for each of the attitude subscales when responded to on a four point Likert type scale ranged from 3.28 to 1.84. The scores indicate that teachers in primary schools in Singapore are confident in computer use, competent in ICT use, have a positive attitude to ICT learning and see relevance in ICT use for teaching and learning. The low mean score of 1.84 for teachers’ computer anxiety scale indicates that teachers in Singapore are not experiencing very much discomfort and nervousness about working with computers.

Teachers’ perception about their principal’s interpersonal behaviour

Table 5
Mean and Standard Deviation of Scales of the PIQ

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Directive</td>
<td>3.90</td>
<td>0.67</td>
</tr>
<tr>
<td>Encouraging</td>
<td>3.49</td>
<td>0.74</td>
</tr>
<tr>
<td>Understanding</td>
<td>3.69</td>
<td>0.83</td>
</tr>
<tr>
<td>Giving Independence</td>
<td>3.64</td>
<td>0.61</td>
</tr>
<tr>
<td>Uncertain</td>
<td>2.11</td>
<td>0.60</td>
</tr>
<tr>
<td>Disapproving</td>
<td>2.37</td>
<td>0.81</td>
</tr>
<tr>
<td>Aggressive</td>
<td>2.29</td>
<td>0.82</td>
</tr>
<tr>
<td>Strict/Inflexible</td>
<td>2.86</td>
<td>0.69</td>
</tr>
</tbody>
</table>

The sample consisted of 476 teachers in 7 schools

Range of 1 to 5

As indicated in Table 5, the teachers perceive their principal as demonstrating directive, understanding, giving independence and encouraging behaviours quite often. The principals’ strict/inflexible, disapproving and aggressive behaviours are less noticeable. Their uncertain behaviour is the least noticed. The teachers perceived the directive behaviour most favourably with a score of 3.90 and the uncertain behaviour least with a score of
2.11. The standard deviation for all the scales ranged from 0.60 to 0.83, suggesting that there was not a large diversity in the teachers’ perceptions.

The teachers’ actual perceptions of the principals can also be depicted as in Figure 2. The profile shows relatively high scores on the scales of Directive, Encouraging, Understanding and Giving Teachers Independence. This result has some similarity to the teacher typology Type 2 as described by Brekelmans, Levy, and Rodriguez (1993). This type of teacher (and in this case the principal) was categorised as ‘Authoritative’. However, the profile shown here shows that the teachers are giving more independence than in the Brekelmans et al. study. Cresswell and Fisher (1998), reported a similar result in Australia, where like the principals in Singapore primary schools, there were relatively high scores on the cooperative side of the profile.

![Figure 2](image.png)

*Figure 2.* The average profile of teachers’ actual perception of principals’ interpersonal behaviour in the seven primary schools in the study.
Associations between teachers’ perception of principal-teacher interactions and their attitudes toward the use of computer technology in teaching and learning in the school

The results of the correlation analyses are presented in Table 6. The principals’ directive encouraging, understanding, and giving independence behaviours have statistically significant positive associations with the teachers’ attitude to ICT training, perceived confidence and perceived relevance in ICT use in teaching and learning, while the principals’ uncertain, disapproving, aggressive and strict/inflexible behaviour were negatively associated with the same three attitudes. When the principals were encouraging and gave their teachers independence, the teachers perceived they had greater competency in ICT use. However, if the principals appeared uncertain then the teachers thought that they were less competent. The more uncertain, aggressive, disapproving and strict/inflexible the principals were the more anxious the teachers were about using computers. When the principals were encouraging, understanding and gave more independence to teachers, the teachers’ anxiety and nervousness was reduced.

Table 6

| Scale               | Simple Correlations (r) | | | | |
|---------------------|-------------------------|---|---|---|
|                     | Computer Anxiety | Perceived Competency in ICT Use | Attitude to ICT Training | Perceived Confidence in ICT Use | Perceived Relevance in ICT Use |
| Directive           | 0.19**               | 0.12**              | 0.16**              | 0.16**              | 0.16**              |
| Encouraging         | –0.17**              | 0.16**              | 0.25**              | 0.20**              | 0.19**              |
| Understanding       | –0.10*               | 0.04                | 0.15**              | 0.10**              | 0.18**              |
| Giving Indep.       | –0.19**              | 0.14**              | 0.23**              | 0.17**              | 0.20**              |
| Uncertain           | 0.15**               | –0.12**             | –0.26**             | –0.19**             | –0.24**             |
| Disapproving        | 0.17**               | –0.19**             | –0.15**             | –0.20**             | –0.15**             |
| Aggressive          | 0.12**               | –0.12**             | –0.11**             | –0.15**             | –0.15**             |
| Strict/Inflexible   | 0.16**               | –0.14**             | –0.13**             | –0.21**             | –0.21**             |

** p< 0.01, *p<0.05

The multiple correlations (R) between the set of PIQ scales and attitudes toward use of computer technology in teaching and learning ranged from 0.28 to 0.35 and are statistically significant (p<0.001) as shown in Table 7. The R² value which indicates the proportion of variance in attitudes toward use of computer technology in teaching and learning can be attributed to teachers’ perception of the principals’ interpersonal behaviour ranged from 8 to 12%. For each scales of the PIQ, the standardised regression coefficients (betas) were determined to establish which of the PIQ scales contributed most to these associations.

It was found that in particular, the encouraging and understanding behaviours of the principals were significant in promoting a positive attitude toward the use of computer technology among their teachers. The same behaviours were important in reducing the teachers’ anxiety. On the other hand when the principals appeared uncertain on IT matters they impacted negatively on teachers’ attitudes and created some anxiety.
Table 7
Significant Standardised Regression Coefficients (betas) Between PIQ Scales and Attitudes Toward Use of Computer Technology

<table>
<thead>
<tr>
<th>Scale</th>
<th>Standardised Regression Coefficient (beta)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Computer Anxiety</td>
</tr>
<tr>
<td>Directive</td>
<td></td>
</tr>
<tr>
<td>Encouraging</td>
<td>-0.26***</td>
</tr>
<tr>
<td>Understanding</td>
<td>-- 0.25**</td>
</tr>
<tr>
<td>Giving Indep.</td>
<td>-0.17**</td>
</tr>
<tr>
<td>Uncertain</td>
<td>0.15**</td>
</tr>
<tr>
<td>Disapproving</td>
<td></td>
</tr>
<tr>
<td>Aggressive</td>
<td></td>
</tr>
<tr>
<td>Strict/Inflexible</td>
<td></td>
</tr>
</tbody>
</table>

R | 0.28*** | 0.29*** | 0.35*** | 0.30*** | 0.30*** |
R² | 0.08   | 0.08   | 0.12   | 0.09    | 0.09    |

*** p < 0.001, ** p <0.01

CONCLUSIONS

This study contributes significantly to the research field of principal-teacher interpersonal behaviour in the school environment in a number of ways. In particular, it has provided, for the first time, validation details for the PIQ and CAS for use with Singapore primary schools and future studies will be able to use these questionnaires with confidence. They also have this data set with which to make comparisons. Importantly, analyses of the data collected in the study demonstrate that teachers’ perceptions of their principals’ interpersonal behaviour does indeed have an impact on their attitude towards the use of ICT in teaching and learning.

The findings indicate that primary school teachers in Singapore perceived the principal as demonstrating high directive, encouraging, understanding behaviour and gave teachers independence. Furthermore, they also suggest that the implementation of computer technology in the school can be improved if principals demonstrate more of these same behaviours.

The results from this study can provide guidelines for principals in Singapore primary schools who wish to provide their teachers with a more conducive environment to improve the implementation of technology use by the teachers and facilitate the teachers use of this technology for instructional purposes and to develop a more positive and productive interpersonal relationship with their teachers. Perhaps, the same findings can be used in a broader perspective applied to learning environments in areas other than the implementation of ICT across the school curriculum.

REFERENCES


TOWARDS RESPONSE-ABLE MATHEMATICS EDUCATION

Bill Atweh
Curtin University of Technology
Australia

ABSTRACT

While the mathematics education literature during the past fifty years has taken a “social turn” by adopting a variety of sociocultural perspectives, there is a noted absence of discussion of ethics as it relates to the discipline. This absence is paralleled by a lack of consideration of the topic in general education and philosophy in our Western culture. This paper argues that ethical responsibility provides the concerns about social justice, and the construction of critical mathematics education, with moral foundations that, consistent with the writings of Levinas, precede philosophy and forms its basis. Deconstructing the concept of ethical responsibility for the other as its etymological meaning of response-ability, this paper considers its implications to the aims of and pedagogy in mathematics education.

INTRODUCTION

The “social turn” in mathematics education (Lerman, 2000) is well illustrated by the intensification and diversity of research issues in the discipline during the past five decades that adopted social and critical perspectives. In particular, concerns about social justice, or its variants of equity, and diversity (Atweh, 2007), are often raised in writings from this social perspectives. However, very infrequently the discourse of ethics is raised in mathematics education. This is not to say that there has been no concern about ethical conduct or ethical implication in the design of curricula and the teaching mathematics. Similarly, this does not mean that ethics and social justice are two divergent discourses. Here I argue that there are two reasons why thinking about ethics in mathematics education supports, and lays the foundation for the concerns about social justice. First, social justice issues are often constructed as concerns related to the participation of social groups in social activity and their enjoyment of their fair share of social benefits. It has less to do with the outcomes achieved by a particular individual - unless the outcomes are due to their belonging to a social group. They are often silent on issues related to the interaction between two people – say of the same social group. Ethics, on the other hand, is concerned with a face to face encounter and interaction between people irrespective of their social positioning. Secondly, ethical considerations highlight moral responsibility of one to, and for the other. This focus on responsibility establishes social justice concerns as moral obligations, rather than charity, good will or convenient politics. In other words, adopting a social justices approach places knowledge as a servant to justice; while an ethical approach places justice at the service of the moral (Cohen, 2001).

This paper attempts to establish the discussion on the social aspects of mathematics education on the construct of ethical responsibility, with one particular interpretation of the term as response-ability. It attempts to argue for the need to raise ethical concerns as a basis for principles of politics, critique and social justice in the discipline. It bases this understanding on one approach to ethics as the ‘first philosophy’ principles espoused by Levinas. Secondly, it discusses the implication of such an approach to mathematics education. Finally, using two constructs of Productive Pedagogy (Hayes, Mills, Christie & Lingard, 2005) namely Intellectual Quality and Connectedness, it discusses some of the implications of a response-ability approach to the classroom pedagogy in mathematics education.

ETHICAL RESPONSE-ABILITY

The demand for responsibility, or more often in its synonym accountability, is an increasing concern in educational discourse, policy and practice. However the term is used with a variety of meanings. Responsibility is often presented as a requirement or duty that restricts (as in, it is the teachers responsibility to cover the curriculum) as well as enables (as in, evaluating students’ learning is the teachers’ responsibility) or sometimes in the placement of blame (as in, who is responsible for the students’ lack of achievement?). It often posits a conflict between the self-interest and the interests of the other, or the collective - giving a priority to the latter. Ethical codes are constructed under the assumption that norms and regulations need to be set and agreed upon otherwise our “natural instincts” would find teachers lazy or dishonest, and leave students under the threat of marginalisation or exploitation.
If the law or the system does not form a valid foundation of ethical responsibility, what does? Philosophy? As discussed above Western philosophy as often avoided the consideration of ethics. Further, as Levinas argues philosophy is mainly concerned with question of being (ontology) and knowledge (epistemology). The discussion of being and knowledge are achieved by reducing the other to the same (Critchley, 1999) and by dealing with consciousness (Bergo, 1999). For Levinas, ethics is before any philosophy and is the basis of all philosophical exchanges. It precedes ontology “which is a relation to otherness that is reducible to comprehensibility or understanding” (Critchley, 2002, p.11). This relation to the other that precedes understanding he calls “original relation”.

Critchley goes on to point out that the original contribution of Levinas is that he “does not posit, a priori, a conception of ethics that then instantiates itself (or does not) in certain concrete experiences. Rather, the ethical is an adjective that describes, a posteriori, as it were, a certain event of being in a relation to the other irreducible to comprehension. It is the relation which is ethical, not an ethics that is instantiated in relations” (p. 12, italics in original). Using a phenomenological approach, Levinas argues that to be human is to be in a relationship to the other, or more accurately, in a relation for the other. This relation is even prior to mutual obligation or reciprocity. Roth (2007) argues that this original ethical relationship discussed by Levinas consists of an “unlimited, measureless responsibility toward each other that is in continuous excess over any formalization of responsibility in the law and stated ethical principles”.

In his later work, Levinas (1997) introduced the distinction between saying and the said in the face to face encounters with the other. The said, for example, philosophical dialogue, is propositional while the saying is the ethical. Neyland (2002, 517) explains the distinction in this way:

> When I speak to another person, I acknowledge him or her as another person. Thus, he puts it, before every said there is a “saying”. When I acknowledge another person, when I focus on his or her “face” I do more than just gaze, I actually encounter him or her. This encounter, Levinas argues, is, at its deepest level, an awareness of the other as one who in some way needs me. This … is the source of the social bond. He emphasises that there is compulsion involved. I am not obliged to respond to the other. I can choose to break the encounter. But in doing so, I weaken the social bond. Further, because my selfhood- my self concept and self identity – depends on my responding to the need I recognise in another, when I break the social bond, I impair my selfhood.

The construction of ethics based on the “original relation” with the other is not apolitical. Critchley (2002) points out that many of Levinas writings present ethics as a critique of politics. He adds that Levinas “wants to criticise the belief that political rationality can answer political problems” (p.24). Rather, ethics inevitably leads into political concerns of social justice (Caygill, 2002). In a chapter on the Politicizing of Mathematics Classroom, Noddings (1993) discusses the role of the mathematics classroom in hindering the development of students as responsible persons. She highlights the need to involve students with shared responsibility of content assessment and the level of mathematics they engage in and assessment. The challenge is not only to produce competent mathematicians and mathematics users but ultimately to promote “the growth of students as competent, caring, loving and loveable people” (159). She calls for increasing needs for mathematics educators to “consider the ethical and political dimensions of learning mathematics as well as the cognitive aspects” (159).

Puka (2005) argues that the great contribution to ethics is the feminist (see Chanter, 2001) distinction between responsibility and "response-ability." Response-ability highlights the ability to respond to the demands of our own well being and the ability to respond to the demands of the other. This is similar to what Roth (2007) points out that, responsibility “etymologically derives from a conjunction of the particles re-, doing again, spondere, to pledge, and – ble, a suffix meaning “to be able to.” Responsibility therefore denotes the ability to pledge again, a form of re-engagement with the Other who, in his or her utterances, pledges the production of sense. Each one on his or her own and together, we are responsible for the praxis of sense, which we expose and are exposed in transacting with others” (p. 5).

Puka goes on to state that a:

response-ability viewpoint makes better sense of our responsibilities toward ourselves as well, including our growth or development and our personal integrity. The standard picture of self-responsibility, where we force ourselves to do things, cannot represent the self-discipline or self-determination involved as true freedom--except through sleight of hand abetted by self-delusion. And ethics must be free; it must organize voluntary cooperation, not cooperation-or-else. By contrast, self-response-ability focuses us on our own worth and the value of our talents or potentials. It enhances our self-appreciation and rests on our predictable response to what we really are and can become.
TOWARDS A SOCIALLY RESPONSIBLE MATHEMATICS EDUCATION

This ethical response-ability discussion applied to mathematics education posits the primary aim of mathematics education to enable the response-ability of the student in their current and future lives as citizens. Undoubtedly, mathematics is an important subject in the curriculum and in the current and future lives of students. In the minds of many such importance is given to the subject due to the increasing importance of technology and science two essential areas in problem solving and raising living standards. Mathematics, like science, is often associated with economic development of a country (Kuku, 1995). At a personal level, of the student, mathematics is often justified as opening the doors to many careers and courses of further study.

However, these assumptions about the value of mathematics education for the student and society should not be accepted uncritically. First, the relationship of mathematics to the general economic development is far more complex than is often assumed. For example, Woodrow (2003), citing the example of the development of the Asian economies and their high achievement on their students on international testing, argue that increases in mathematics education standards have occurred after their economic development, and arguably as a result of it, rather than the other way around. Further, Ortiz-Franco and Flores (2001) demonstrate how during the period between 1972 and 1992, the mathematics achievement of the Latino students in the USA have increased with comparison to the other students, however their socioeconomic status has decreased.

Similarly, the assumption that mathematics is needed to increase access of students to jobs as a justification of its place in the curriculum should be regarded with care. The dominance in school mathematics of content needed for careers that are seen as mathematically based – mainly science and engineering, is unwarranted and, perhaps, is a residue of times when few students finished high school and went to university. Notwithstanding the importance of jobs in science and engineering for social technological development, only few students end up in such careers. Further, with advances in technology, the demand for most calculations and algorithms that still dominate the majority of school teaching is increasingly becoming obsolete. Arguably, the nature of mathematics used in society has changed more rapidly than school curricula.

Here I argue that all students need mathematics for effective citizenship in an increasingly mathematised world of today. Not only a significant amount of mathematical thinking is behind most day-to-day decisions that people make, but also as Skovsmose (1998) asserts, mathematics plays a role in “formatting” the world. In other words it creates a social and physical world after its own image. This power of mathematics is, of course, double edged. On one hand great achievements in science and technology are mathematically based. But also mathematics is implicated in technologically caused catastrophes ala wars and mass destruction (D’Ambrosio, 1998). Hence, a utilitarian approach to mathematics falls short of developing a response-able student. As Ernest (2002) argues a critical approach to mathematics and citizenship is needed.

Developing mathematical knowledge and capacity helps the students not only, using Freire’s (in Gutstein, 2003) terminology, to “read the world”, i.e. understand it, but it should lay the foundation for their capacity to “write the world”, i.e. change it. In traditional wisdom of school mathematics, reading the world (at least some aspects of it) is the function of the school; while writing the world is often constructed as a possible capacity that might arise later when the students enter the work life and civil society. Borrowing the terminology from Down, Ditchburn and Lee (2007), the role of mathematics education as it relate to citizenship can be at three levels. Mathematics education can contribute to the ability of students to function as effective citizens in the world. The authors call this a conforming ideal. This is consistent with the dominant justification of mathematics as developing skills and knowledge useful for preparation for jobs. However, mathematics can also be used to enable student to understand how the world works (or does not work) in order to change aspects of their world. This, the authors call reforming. However, mathematics has an additional capacity. It can be used to create the world in a new way. The author calls this the transforming capacity. This focus on mathematics education is consistent with the critical mathematics movement. Some examples of activities designed with this focus will be discussed below.

In the following two sections, I will discuss some implications for this response-able approach to mathematics education for classroom teaching. In particular, I will discuss two dimensions of the Productive Pedagogy (Hayes, Mills, Christie & Lingard, 2005), namely Intellectual Quality and Connectedness, from this ethical response-ability perspective as they relate to the teaching of mathematics.

RESPONSIBLE-ABILITY AND INTELLECTUAL QUALITY

In the dominant traditional mathematics education discourse, intellectual quality is often understood as the mathematical abstraction and the rigor of academic mathematics. This includes formalized symbolic language,
axiomatic thinking, standard efficient algorithms and proofs. It also includes sophisticated modelling of mathematically-based problems—usually from areas such as physical reality, engineering and the economy, in which there is a unique or best fit solution. This is often contrasted with practical mathematics that focuses on real world applications, routine problem solving—on personalised (often called student-invented) algorithms, solutions and presentations of mathematical arguments. In many Australian curricula these two types of mathematics are contained in separate alternative streams that students chose between depending on their previous mathematics performance (often taken as a sign of ability) and post school aspirations. This construction of intellectual quality of mathematics as a dichotomy between formal and practical mathematics is presented as a common sense argument for providing a greater choice (a valuable endeavour in neo-liberal politics) for students and to cater for the needs of a larger number of students. However, this binary might be counter productive by denying the majority of students taking the so-called social or practical mathematics the opportunity and the ability to develop their generalised abstractions of mathematical concepts and procedures. Further, in spite of the rhetoric of curriculum documents, and the assurance by many teachers that the two streams deal with equally valuable mathematics—albeit for different needs—for many students a hierarchy of values exist between them giving higher status to the formal academic mathematics.

Seen in this way, intellectual quality of mathematics is measured primarily from within the discipline itself rather than the usefulness of that knowledge to the current and future everyday life of the student. In other words, intellectual quality is measured by the level of decontextualisation and abstraction of the discipline and in isolation to social questions and issues into which it can be applied. In particular there is a resistance by many mathematics teachers and curriculum to deal with controversial social issues as a source of examples of mathematical problems. Perhaps because of the common belief that mathematics deals with objective reality, less often does school mathematics deal with issues of socio-political aspects in society such as distribution of wealth, disadvantage and demographical changes. These social issues are often seen by mathematic teachers and curriculum designers as belonging to other subjects in the curriculum. This demarcation is consistent with the separation of the realm of the know-how of science and technology and questions of values and morality dealt with in the social sciences and philosophy.

Undoubtedly, developing the capacity of students to master the language and findings of mathematics, and even its formality is a contribution to students’ response-ability as active citizens. As Ernest (2002) argues empowerment of students in and through mathematics necessarily includes mathematical empowerment which consists of the ability to critically read and produce mathematical texts as well as pose their own problems and solve problems. With the transforming the world aim of mathematics education, perhaps a different type of mathematics and different ways of teaching may be necessary. First, the development of mathematics in isolation to the capacities developed in other areas of school curriculum limits the role of mathematics in achieving its transformative potential. A more interdisciplinary approach is essential. Further, the privileging of abstract knowledge over contextualised knowledge becomes problematic. As Christie (2005) argues, “current times require the consideration of both universalistic, abstract knowledges and particularistic, contextualised knowledges” (244). Seen from this perspective, intellectual quality looks different to the above construction. Quality in mathematical education is measured not as, or not only as, formal abstraction and generalisation, but by its capacity to transform aspects of the life of the students both as current and future citizens.

RESPONSE-ABILITY AND SOCIAL CONNECTEDNESS OF KNOWLEDGE

Mathematics can only contribute effectively to student response-ability if it engages with the world of the students. Perhaps every teacher of mathematics at one time or another has faced the question from a distressed student “but why are we studying this?”. Perhaps not surprisingly, the usual answer that you need this for future jobs leaves many students unsatisfied, if not unconvinced. Here I argue that the usefulness of mathematics should not only be demonstrated by using examples from the real world of the student as applications of mathematics, but also mathematical knowledge should be developed through such activities. The development of mathematical knowledge through real world activities demonstrates the usefulness of mathematics at the same time as engaging students. Further, this engagement of mathematics with the life of the student should be an engagement not only with the physical world and the economic world, but also with the social world; not only with the world as the student will experience as an adult, but their current world; it should aim at developing an understanding not only of mathematics but also an understanding of the world. Finally, such engagement should aim at not only reading the world but also, whenever possible, at transforming the world—even to a small degree. Let us consider some examples of mathematics activities described in the literature that aimed to establish such a connection with the world of the student.
The first example reported in the literature is by Gutstein (2003) who reported on a series of 17 mathematics activities spanning two years in a Latino urban school in which his students were involved in to highlight inequalities in their social world. In describing the activities, Gutstein commented that in his class he normalised the discussion of “taboo subjects” in many mathematics classrooms including racism, discrimination, power and justice. One example of such an activity was the distribution of wealth where the students compared the wealthiest 1% of the USA with the bottom 80%. Prior to giving the data, students were asked to guess the distribution – with an interesting pattern that most guesses were more equitable than the real data showed. Inevitably, such an activity did lead to strong emotions of anger and sense of unfairness with some of the students. In another activity students looked at racial and socioeconomic data as they are portrayed in the SAT test distribution.

The above example illustrates how students can be engaged in real world data to develop their ability to critically understand aspects of their social world as they are developing mathematics concepts and skills. The second example given here, even though it has not evolved from within the mathematics classroom, required a significant amount of mathematical thinking and data handling. Further, it illustrates how mathematics knowledge can be used to change aspects of the students’ world. Holdsworth, (2004) reported on a study that about 80 students from an area where young people constitute a significant percentage of road fatalities have formed Student Action Teams to conduct research and suggest changes to traffic conditions around their schools. Working collaboratively, the students made decisions on what to study, what questions to ask and who needs to be investigated. Some students have looked at the traffic conditions around their schools while others conducted interviews and surveys. What is significant in this project is that the research teams were asked to come up with recommendations as well as plans towards the achievement of these recommendations.

This approach to mathematics education has two implications for mathematics education. First, the isolation of mathematics from other discipline areas hinders the development of the ability to deal with social transformations. The call here is for a more interdisciplinary approach to mathematics education and the willingness to deal with controversial topics in which debate and difference of opinion and interests are part of the equation rather than nuisance variables. Second, in working towards social transformation, the teachers and students develop a new relationship of co-inquirers or co-learners in contrast to the traditional construction of expert and novice. In such real life activities, while the teacher is not the source of knowledge about what needs to be changed, the students need support in identifying these needs and in negotiating change.

REFERENCES
Atweh, B. (2007). What is this thing called social justice and what does it have to do with us in the context of globalisation? Philosophy of Mathematics Education Journal, 21.


AN INVESTIGATION INTO THE EFFECTIVENESS OF USING ANALOGIES TO TEACH AND LEARN SCIENTIFIC CONCEPTS

Florence. N. Ballard, and David. F. Treagust,
Curtin University of Technology
Australia

ABSTRACT

Educators are constantly looking for effective teaching strategies, which can engender a favourable conceptual change in students within a constructivist paradigm. Teaching science with analogy could be one of such instructional strategies found effective in motivating students by providing them with familiar and tangible visual stimuli taken from the students’ world to provide a basis for bridging and promoting associations between a known and an unknown realm, thus making a complex, abstract concept simple and interesting by reducing or eliminating students’ misconceptions and alternative frameworks. This study was undertaken to find out whether a systematically planned and presented analogy using the FAR Guide has the capacity to enhance student understanding, remove misconceptions and alternative frameworks and improve higher order thinking. The sample consisted of 154 students from Yeronga State High School, Education Queensland, Australia, which caters for learners coming from 50 different ethnic groups settled in Australia. English is a second language for many of these students. Five different analogies were presented to students in grades 8, 11 and 12, aged 12-18 years, as a component of their science, chemistry and biology lessons respectively. This cohort consisted of 76 boys and 78 girls and the effectiveness of these analogies was studied by collecting qualitative and quantitative data. The results showed a statistically significant increase in the scores from the pretest to posttest, indicating improved understanding and higher order thinking. There was a considerable decrease in student misconceptions and alternative frameworks.

BACKGROUND

It is generally recognized that analogies can facilitate the generation of meaning through a constructivist pathway (Duit, 1991). The Teaching With Analysis (TWA) model (Glynn, Duit, & Thiele, 1995) provides guidelines for using analogies and the purpose is to transfer ideas from a familiar concept (analog) to an unfamiliar one (target). If the analog and target share similar features, an analogy can be drawn between them. This teaching model involved six teaching operations such as the introduction of the target concept, review of the analog concept, identification of the relevant features of target and analog, mapping similarities, indicating where the analogy breaks down and drawing conclusions about the target concept. It is imperative that the teacher and students hold a common view of the analog model before the mapping begins. Though the TWA model paved the way to refined teaching approaches, the model itself was not always successful in its application due to the number of steps involved in its implementation. Search for a simpler, effective and teacher-friendly teaching model brought out the FAR Guide (Treagust, Venville, Harrison, Stockmayer, & Thiele, 1995), the acronym for Focus, Action and Reflection. The students concentrate on the target and analog (Focus), look at the features of both the target and analog to draw similarities and dissimilarities (Action) and draw their conclusions (Reflection). The teacher facilitates the above operations until the students learn to use analogies effectively by sifting through the unshared attributes and focusing on the essential shared attributes for correlation. The incorporation of the FAR Guide is likely to be advantageous in teaching science to promote better use of analogies and better understanding of scientific concepts. However, the effectiveness of the use of the FAR Guide is yet to be fully demonstrated (Treagust, Harrison & Venville, 1998). Such a situation necessitates further research, employing diverse research designs for a significant period of time. This research is such an attempt, which investigated the effectiveness of using the Guide to present analogies to teach and learn scientific concepts and the role they play in conceptual change. This study investigated whether the analogies had the potential to: a) enhance student understanding of science concepts, b) reduce the incidence of misconceptions and alternative frameworks and c) enhance the ability of students to extend their thinking to higher levels.

SIGNIFICANCE

The study is significant for the following reasons:

Firstly, it looked at the chosen analogies and analysed them for their merits in bringing about a better understanding of scientific concepts; consequently, their effect on student understanding and a means of enhancing the quality of science education,
Secondly, it looked for evidences that revealed reduced misconceptions and alternative conceptions after presenting the analogies based on the assumption that these analogies will contribute to the students’ perception of the concept as a whole, thus laying the right foundation for future construction and performance in science related studies and daily life activities.

Thirdly, it looked for evidences for enhanced higher order thinking skills in students, since the ultimate goal in educating students is based on the conviction that “… knowledgeable thinkers have a better chance of taking charge of their lives and achieving personal advancement and fulfilment … students must be prepared to exercise critical judgement and creative thinking to gather, evaluate, and use information for effective problem solving and decision-making in their jobs, in their professions and in their lives” (Swartz & Parks, 1994).

**RESEARCH METHODS**

The research proceeded in three stages; the initial data collection about baseline understanding, implementation of teaching analogies with the FAR Guide and post-instruction data collection and analysis. This study used an exploratory and inductive qualitative approach that provided descriptive details (interview, classroom observation and reflective comments) and a quantitative approach, (pretest and posttest results of the two-tier diagnostic instruments) to arrive at generalisations based on statistical projections. The pretest results were not revealed to the students until the posttest was completed and evaluated. The five chosen analogies were designed cautiously to eliminate and minimise any discrepancy or ambiguity between the analog and target. They all had the qualities, which were appealing to the students. They were deliberately made to appear different from the regular ‘chalk and talk’ method and all the visuals were made colourful and attractive with appropriate titles, labels and short notes and projected on a big screen for better viewing; thus gaining maximum attention from the learners to perceive the analog-target relationship. Two examples relating to real life situations, an outdoor-game, a cut and paste paper craft activity and a partly animated Power Point presentation were presented as analogies. It was obvious from the students’ reflective comments that they had enjoyed the change from routine classroom teaching. The diagnostic instruments were carefully structured so that the included multiple choices would readily bring out the understanding of the concept and misconceptions held by the students, both prior to and after the presentation of the analogies. By using these diagnostic instruments at the beginning or on completion of a specified topic, science instructors can achieve better understanding about the nature of students’ understanding and the existence of any alternative conceptions or misconceptions in a particular topic being studied (Treagust, 2006). This research followed specific stages in addressing the research questions and did not predetermine or delimit the direction the investigation took in its course.

The research proceeded in three stages with the three objectives mentioned earlier:

**First stage:**
- The targets were chosen from the curriculum and appropriate analogies were selected/created to suit the scientific concept; Initial mapping and further analysis of analogies were carried out for suitability and incorporation as a part of the lesson.
- The chosen concepts were presented to the students **without the analogies**.
- The Two-tier Diagnostic Instruments (Treagust, 1985) were cautiously structured to test student-understanding, misconceptions and higher order thinking levels and conducted; the results were tabulated and analysed.

**Second stage:**
- The FAR Guide was introduced to the students and they were trained to use the Guide effectively. (In addition, printed materials which explained the use of the Guide including a few simple worked out examples showing the target - analog mapping were distributed)
- Then, the corresponding analogs were presented to elaborate the associated concept.
- Students’ and teacher’s observation and reflective comments were recorded.
- The students were tested again using the same Diagnostic Instrument; the results were tabulated and analysed.

**Third stage:**
- The students were encouraged to give their reflective comments in writing and these comments were further discussed. A few were randomly selected and interviewed to determine the level of their individual conceptual development and their responses were audiotaped.
- The students’ flexibility in thinking was tested by asking them to apply the concept to new situations by generating their own analogies.
- The students’ higher order thinking was tested from their own constructed analogies and the elicited written and verbal responses on target-analog relationship.
THE FAR GUIDE FOR THE ANALOGY ON ATOMS AND MOLECULES

FOCUS

<table>
<thead>
<tr>
<th>Concept</th>
<th>Is it difficult, unfamiliar, or abstract?</th>
<th>The chosen concept ‘Atoms and Molecules’ is difficult, unfamiliar and abstract.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td></td>
<td>The students have a very limited knowledge of the concept. They were never taught this concept before.</td>
</tr>
<tr>
<td>Analog</td>
<td></td>
<td>The students are familiar with similar games like the chosen analog, ‘Fill up the orbit’.</td>
</tr>
</tbody>
</table>

ACTION

| Likes                  | Discuss the features of the analog and chosen science concept. Draw similarities between them. | An atom could be compared to the chosen game, in which the central circle represents the nucleus of the atom and it contains the card showing the atomic and mass numbers. The students standing around in concentric circles represent the electrons. (Refer to ‘Similarities mapped out in detail’). |
| Unlikes                | Discuss where the analog is unlike the science concept. | The analogy game was designed to resemble the actual structure of the atom largely. There will be a discussion in the class and the students will be encouraged to raise the dissimilarities, discuss and make conclusions. |

SIMILARITIES MAPPED OUT IN DETAIL

<table>
<thead>
<tr>
<th>ANALOG</th>
<th>ANALOG -FEATURES</th>
<th>TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>The inner circle</td>
<td>A card containing the name of the atom, its atomic and mass numbers, from which the number of the subatomic particles could be easily calculated.</td>
<td>The nucleus containing protons, and neutrons of the atom and their numbers.</td>
</tr>
<tr>
<td>Outer circle 1</td>
<td>A maximum of 2 students standing within the second circle, outside the inner circle.</td>
<td>Duplet rule – The first orbit can accommodate a maximum of two electrons.</td>
</tr>
<tr>
<td>Outer circle 2</td>
<td>A maximum of 8 students standing outside the 2nd, but within the third circle.</td>
<td>Octet rule - The second orbit can accommodate a maximum of eight electrons.</td>
</tr>
<tr>
<td>Outer circle 3</td>
<td>The remaining students were to stand outside the third circle. (Since it is grade 8 level and only the basic structure was required, the atoms with electrons that would fill up the first 3 orbits alone were chosen as examples).</td>
<td>Once the 1st and 2nd orbits have reached the maximum electronic configuration, the remaining electrons would fill in the 3rd orbit.</td>
</tr>
<tr>
<td>Completed 1st circle</td>
<td>Only 2 students are permitted to stay within the 2nd circle.</td>
<td>The atom has attained a complete and stable electronic configuration.</td>
</tr>
<tr>
<td>Completed 2nd circle</td>
<td>Only 8 students are permitted to stay within the 3rd circle.</td>
<td>The atom has attained a complete and stable electronic configuration.</td>
</tr>
<tr>
<td>Incomplete 1st/2nd/3rd circles</td>
<td>The remainder of the respective group stand within the 4th circle.</td>
<td>Incomplete/unstable electronic configuration.</td>
</tr>
<tr>
<td>Complete outermost circle</td>
<td>Maximum number of students filling up the outer circle.</td>
<td>Full valence shell/orbit.</td>
</tr>
<tr>
<td>Incomplete 1st/2nd/3rd circles</td>
<td>Less number of students than the maximum that could be accommodated.</td>
<td>Can receive or give away electrons to attain a stable electronic configuration and get charged to form an ion.</td>
</tr>
<tr>
<td>Complete outer circle</td>
<td>Two students filling up the 1st orbit, 8 students, if it is the second or third orbit</td>
<td>There are elements, which have complete outer orbits, such as the inert gases, will neither give away nor receive electrons from any other atom.</td>
</tr>
</tbody>
</table>
The students enjoyed the game. During analog-target mapping, the students brought up the likes and dislikes, which were listed on the board for the students to copy. A few questions were asked to bring out their understanding and thinking process to a certain extent. Many said that the game clarified a few of their uncertainties.

<table>
<thead>
<tr>
<th>Improvements</th>
<th>If needed, refocus and redesign in the light of outcomes</th>
</tr>
</thead>
</table>

The students felt that the leader should be changed for every game so that all of them would have a chance to get familiar with the rules. From their comments, it seemed that the students were benefited from the analogy.

The rules of the game, ‘Fill up the Orbit’ were established to bring out the essential features of the abstract target, which is the atom. Each student received a copy of the picture (given below) and the analog-target mapping was done in detail. After this, the game was played outside the classroom.

Figure 1. Fill up the orbit (an analogy - a game).

<table>
<thead>
<tr>
<th>Group A - GIRLS</th>
<th>Group B – BOYS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner circle = Nucleus</td>
<td>Inner circle = Nucleus</td>
</tr>
<tr>
<td>Concentric circles-Orbits</td>
<td>Concentric circles-Orbits</td>
</tr>
<tr>
<td>Students = Electrons</td>
<td>Students = Electrons</td>
</tr>
<tr>
<td>Protons</td>
<td>Protons</td>
</tr>
<tr>
<td>Neutrons</td>
<td>Neutrons</td>
</tr>
</tbody>
</table>

![Fill up the orbit](image_url)
DETAILS OF THE GAME

The class was divided into TWO teams, A & B, boys versus girls. Each group chose a leader. Two sets of four concentric circles were drawn on the floor as shown in the figure. The students were told that they were electrons, revolving around the nucleus in their orbits. The innermost circle represented the nucleus. A card containing the name of the element, its atomic and mass numbers was placed upside down inside the inner circle. When the teacher gave the ‘start’ signal, the students ran to the inner circle, flipped the card and read the data. They then calculated the number of protons, neutrons and electrons of the element using the information and filled up the ‘orbits’ in consistency with the duplet and octet rules. Those who had completely filled up the orbits started moving around in their respective circles and the excess moved out. Then they sat down to show that they had completed the electron configuration. The leader had to call out whether they would give up or gain electrons to attain a stable electronic configuration, also the resulting charge. There was a trial, followed by six games with six different elements.

Figure 2. Examples of cards used in the game.

<table>
<thead>
<tr>
<th>GAME 1</th>
<th>GAME 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Na</td>
</tr>
<tr>
<td>19</td>
<td>11</td>
</tr>
<tr>
<td>FLUORINE</td>
<td>SODIUM</td>
</tr>
</tbody>
</table>

ANALYSIS OF RESULTS

A paired samples t-test was conducted to evaluate the impact of the instruction incorporating each of the analogies on students’ performance in the diagnostic tests. The results showed a statistically significant increase in the scores from the pretest to the posttest. A paired-samples t-test conducted to evaluate the effect of the instruction on students’ total diagnostic test scores on “Cell Structure and Function” showed a statistically significant increase from the pretest (M=5.39, SD=2.11) to the posttest (M=6.34, SD=1.60, t(37)=3.39, p<0.01). The Cohen’s d statistic of 0.51 indicated a medium effect size. The same test for ‘Atoms and Molecules’ showed an increase from the pretest (M=4.28, SD=1.56) to the posttest (M=5.11, SD=1.70, t(45)=3.26, p<0.01) and the Cohen’s d statistic of 0.51 indicated a medium effect size. The paired-samples t-test for ‘Atoms and Molecules’ also showed an increase from the pretest (M=4.24, SD=2.50) to the posttest (M=5.48, SD=2.24, t(24)=2.89, p<0.01) and the Cohen’s d statistic of 0.52 indicated a medium effect size. The same test for ‘Cell Structure and Function’ showed an increase from the pretest (M=4.36, SD=2.40) to the posttest (M=5.41, SD=2.59, t(21)=2.33, p<0.01) and the Cohen’s d statistic of 0.42 indicated a medium effect size. The paired-samples t-test for ‘Crossing Over’ showed an increase from the pretest (M=2.87, SD=1.71) to the posttest (M=5.04, SD=2.36, t(22)=4.72, p<0.01) and for this analogy, the Cohen’s d statistic of 1.05 indicated a large effect size.

Higher order thinking requires students to manipulate information and ideas in a way that transform their meaning and implications. This transformation occurs when students combine facts and ideas in order to synthesise, generalise, explain, hypothesise or arrive at some conclusion or interpretation (Education Queensland, 2002). 24% of the Two-tier diagnostic questions required higher order thinking and the rest were directly or indirectly related to the analogies given. The average score for the higher order responses was 46.85% in the pretest and 54.79% in the posttest, showing an increase of 7.94% after the presentation of analogies. The students were prompted to generate their own analogies, which could be taken as an indication of higher order thinking in students, and many of the students were able to generate analogies either for the whole concept or a part of the concept.

The following are the student generated analogies (Year 8) for the structure and function of a Cell:

- A cell is like an oil ship or a cargo ship. The nucleus is the captain and the DNA is the chart. The mRNA particles are the first mates and the cell membrane corresponds to the deck and hull.
- The cell is like my house. All the dirt and other things, which fill up the house, are like the cytoplasm. The walls and doors make up the cell membrane and the lights are the chloroplasts, if it is a plant cell. The power box is the mitochondria and the hall way is the endoplasmic reticulum.

Student-generated analogies from year 12 for Protein synthesis:
Baking a cake: Recipe obtained from a book/computer (DNA), the Ingredients are noted (mRNA), Shopping for ingredients (tRNA), Mixing the ingredients and baking the cake (ribosomal RNA)

A hamburger factory: Main computer prints out the recipe, people go about and take the recipe to the store, store worker collects the materials, people take parts/materials back to workers and the hamburger is produced.

Student-generated analogies from Year 12 for the Crossing over of chromosomes are given below:

- Doing the activity with ribbon or string instead of paper because then we can actually show the twisting quite easily and then we would cut it and see how it is evenly intertwined within each non-sister chromosome.
- Another analogy can be arranging different beads in a necklace and swapping over.
- Kebab sticks with meat and different vegetables threaded through and then rearranged between two.

**STUDENTS' OPINION ON TEACHING WITH ANALOGIES**

**From Year 8 – on Atoms and Molecules:**

- ‘I prefer teacher using analogies to simplify structure and functions of objects, as it is a great way to learn as it puts the subject to things I know’.
- (I prefer) ‘The atom game because we had to put our knowledge to test so we could win’.
- ‘When I do something, I remember it’.
- ‘. . . we had a chance to be inside or feels what it is like to be inside an atom’.

**From Year 12 – on Protein Synthesis:**

- ‘Teaching with analogy makes concepts easy because it clearly and specifically informs you the key concept’.
- ‘It was clear and useful as I can now refer to this (analogy) and then can think of the scientific wording for the certain situation. I also learn well visually and with the diagram I can think back and picture it’.
- ‘Yes, my opinion on teaching with analogy to make certain scientific concepts easy is very good because the students would understand the message clearly. Yes, the analogies did help me learn more about cells and protein synthesis’.

**MISCONCEPTIONS**

Though the misconceptions were considerably reduced after learning with analogies, the students still hold a number of misconceptions and these can only be eliminated as time passes by, with repeated revisits of the topic when the students move up to higher levels. Knowledge of these prevailing misconceptions helps a teacher to plan effective remedial programmes to remove these misconceptions.

**CONCLUSION**

The incorporation of the FAR Guide could be a valuable tool in teaching science to promote better use of analogies and better understanding of scientific concepts, provided the teacher and students follow the course of action specified by the FAR Guide. The teacher needs to design an analogy to suit the concept with maximum shared and minimum unshared attributes and facilitate the above operations until the students learn to use analogies effectively by sifting through the unshared attributes and focusing on the essential shared attributes for correlation. It is imperative that a thorough analog-target mapping is done with the students if the analogy is to be effective and beneficial to the students.

**ACKNOWLEDGEMENT**

We would like to thank Mr. Alan Jones, Principal of Yeronga State High School, who showed appreciation and interest in this study during his tenure at the above school, Mr. Terry Heath, the current Principal, who has graciously permitted to continue the study and finally, Education Queensland, for the policies and incentives, which encourage teachers to take on innovative strategies in education.

**REFERENCES**


Erickson, F. (1986). Qualitative methods in research on teaching. In M. C. Wittrock (Ed.), Handbook of research on teaching (3rd ed.) (p119-161). New York: Macmillan.


WORLD WIDE WEB REFERENCES


INVESTIGATING MATHEMATICS STUDENTS’ ATTITUDES TOWARD COMPUTERS AND THEIR INTERACTION WITH ACHIEVEMENT AND GENDER

Anastasios (Tasos) Barkatsas
Monash University, Australia
Vasilis Gialamas
University of Athens
Greece
Katerina Kasimatis
Pedagogical Institute
Greece

ABSTRACT

The aim of the study was to investigate the interaction between the students’ mathematics confidence, confidence with technology, attitude to learning mathematics with technology, affective engagement and behavioural engagement, achievement, gender and year level. The participants were Year 9 and Year 10 students from state co-educational schools in Athens, Greece. For our research we used the Mathematics and Technology Attitudes Scale (MTAS). The five factors extracted by the factor analysis were then subjected to a Multiple Correspondence Analysis. Gender differences as well as differences between Year levels were investigated by using a Test Value (Valuer Test). It was found that boys expressed more positive views towards mathematics and more positive views towards the use of technology in mathematics, compared to girls.

INTRODUCTION

The study reported here was conducted in the metropolitan area of Athens, Greece. The aim of the study was to investigate mathematics students’ attitudes toward computers and their interaction with achievement and gender. The Mathematics and Technology Attitudes Scale (MTAS) was used to examine the role of the affective domain in learning mathematics with technology. MTAS can be used in schools which aim to track changes in the attitudes and engagement of students in their learning of mathematics, in response to the altered learning environment and to consider how best this use of technology can be implemented.

Middleton (1999) put forward a number of reasons that provide a rationale as to why intrinsic motivation for achievement in mathematics is desirable in contemporary mathematics classrooms. He claimed that:

When students engage in activities in which they are intrinsically motivated they tend to exhibit a number of pedagogically desirable behaviors including time on task, persistence in the face of failure, more elaborate and monitoring of comprehension, selection of more difficult tasks, greater creativity and risk taking, selection of deeper and more efficient performance and learning strategies, and choice of an activity in the absence of an extrinsic reward (p. 66).

The researcher also argued that intrinsic motivation is more complex than the additive effects of student ability, perceived competence and achievement desire, even though they significantly contribute to the students’ desire to successfully participate in mathematical activities and to do well in mathematics.

Newmann (1989) however, adopted a somehow different position. He argued that “only when students perceive that academic achievement will lead to rewards they value and, further, believe that their own hard work will result in academic achievement will their engagement increase” (p. 35).

The importance of intrinsic motivation for achievement and participation in advanced mathematics courses, and the apparent differences between boys and girls’ views has been demonstrated by Watt’s (cited in Vale and Bartholomew, in print) argument that: “boys maintained higher intrinsic value for maths and higher maths related self-perceptions than girls throughout adolescence”. The authors also cited a finding from the Program of International Student Assessment (PISA) 2003 study relating to girls’ confidence in mathematics: “females appear to be less engaged, more anxious and less confident in mathematics than males.

Weglinsky (1998) evaluated educational technology and student achievement in mathematics with a USA national sample of 7,146 Year 8 (second year junior high school) students. He reported the following findings: (1) Year 8 students who used technology (simulation and higher order thinking software) gained up to 15 weeks above grade level or about one-third of a year level increase, in mathematics scores. He also reported that “high-achieving students are more likely to use technology in certain ways rather than these uses of technology promote high levels of academic achievement” (p.4).
AIMS OF THE STUDY

The aims of the study were:

- To investigate the factorial structure of secondary students’ mathematics confidence, confidence with technology, attitude to learning mathematics with technology, affective engagement and behavioural engagement, and
- To investigate the influence of students’ demographic data on their mathematics confidence, and confidence with technology and on their attitude to learning mathematics with technology.

RESEARCH METHODS

Sample

The participants were 548 Year 9 (286 male and 262 female) and 520 Year 10 (263 male and 157 female) students from government co-educational schools in Athens, Greece. The schools were randomly selected. In each school one classroom from each year level was randomly selected. These schools are typical of the range of secondary schools in Greece and they vary from upper middle to low socio-economic status.

Students’ mathematics achievement was provided by the students themselves, and it represented their mathematics grades during the year of the study (2004-05). The grades categories are the following: A (80-100%), B (70-79%), C (60-69%), D (50-59%) and E/F (<50%).

Instrument

For our research we used the Mathematics and Technology Attitudes Scale (MTAS) developed by Pierce, Stacey & Barkatsas (2007). The instrument consists of 20 items. A Likert-type scoring format is used for each of the subscales: MC, TC, MT and AE. Students are asked to indicate the extent of their agreement with each statement, on a five point scale from strongly agree to strongly disagree (scored from 5 to 1). A different but similar response set is used for the BE subscale. Students are asked to indicate the frequency of occurrence of different behaviours. A five-point system is again used – Nearly Always, Usually, About Half of the Time, Occasionally, Hardly Ever (scored again from 5 to 1).

According to the scale developers the questionnaire was easy to administer, there were few queries from teachers or their students and it was completed within 10–15 min. The rationale for the selection of the items and the naming of the subscales, as well as the psychometric properties of the scale, may be found in (Pierce, Stacey & Barkatsas, 2005). MTAS subscale scores can be calculated by simple addition of responses. With a maximum possible score on any subscale of 20 and a minimum of 4, we consider scores of 17 or above to be high, indicating a very positive attitude, 13 - 16 to be moderately high and 12 or below to be a low score reflecting a neutral or negative attitude to that component. In what follows, the first part of the statistical analysis for this study will be presented in detail.

DATA ANALYSIS

Factor analysis

The questionnaire items were initially subjected to a factor analytic data reduction (extraction method: Maximum Likelihood). Since no differences were observed in the four initial analyses, a final factor analysis using data from 1068 complete students’ responses to the twenty items forming the MTAS indicates that this data satisfies the underlying assumptions of the factor analysis and that together five components (each with eigenvalue greater than 1) explain 67% of the variance, with almost 16% attributed to the first factor, MC. Reliability analysis yields satisfactory Cronbach’s alpha values for each subscale (MC, 0.92; MT, 0.89; TC, 0.87; BE, 0.77 and AE, 0.68). This indicates a strong or acceptable degree of internal consistency in each subscale.

The five factors that were extracted were identical to the five factors of the original MTAS study (Pierce, Stacey & Barkatsas, 2005):  Mathematics Confidence [MC], Confidence with Technology [TC], Attitude to learning Mathematics with Technology (whether computers, graphics calculators or computer algebra systems in the original scale – computers in this study) [MT], Affective Engagement [AE] and Behavioural Engagement [BE].
Correspondence analysis

The five factors produced by the factor analysis were transformed to ordinal variables with five categories (1 = negative attitude, 2 = rather negative, 3 = neutral, 4 = rather positive and 5 = positive attitude) each by using the method of equally weighted groups, in order to perform a Multiple Correspondence Analysis (with optimal scaling), which uses nominal variables (SPSSwin). The aim of the Multiple Correspondence Analysis was to investigate relationships between students’ Mathematics Confidence [MC], Affective Engagement [AE] and Behavioural Engagement [BE], Confidence with Technology [TC], Attitude to learning Mathematics with Technology [MT]. Furthermore, the analysis could highlight the influence of the demographic and the bio-data on students’ attitudes.

The main variables of analysis were the following five (attitudinal) categorical factors:

- Mathematics Confidence [MC]
- Confidence with Technology [TC] Attitude to learning Mathematics with Technology (whether computers, graphics calculators or computer algebra systems in the original scale – computers in this study) [MT]
- Affective Engagement [AE] and
- Behavioural Engagement [BE]

The supplementary variables were the following:

- Mathematics achievement
- Gender
- Year level

Three factors were extracted from the Multiple Correspondence Analysis (Figure 1). Figure 1 represents the results of the Multiple Correspondence Analysis in a factorial plane.

![Figure 1](image-url)  

Figure 1. 1x2 Multiple Correspondence Analysis factorial plane, representing students’ attitudes towards mathematics and the use of technology in mathematics instruction. 

Factorial axis 1 (Factor 1) represents two opposing categories: the negative part of the axis represents students’ low levels of mathematics confidence, affective engagement and behavioural engagement in mathematics and the positive part of the axis represents students’ high levels of mathematics confidence, affective engagement and behavioural engagement in mathematics. Factorial axis 2 (Factor 2) represents the following two opposing categories: the positive part of the axis represents students’ neutral levels of mathematics confidence, affective engagement and behavioural engagement in mathematics and the negative part of the axis that represents students’ extremely high levels of mathematics confidence, affective engagement and behavioural engagement in mathematics. Factor 3 could be conceptualised as representing students’ attitudes towards technology and towards the use of technology in mathematics instruction.

GENDER DIFFERENCES

In order to investigate gender differences as well as differences between Year levels a Test Value or Valuer Test (Lebart, Morineau & Piron, 1995) was used. The statistics used in the Valeur Test (Test Value) is briefly described in what follows: In order to calculate the magnitude of the differences between percentages or between mean values, statistical tests are being carried out, being expressed in terms of the standard deviations of a normal distribution. The test value is equal to the number of standard deviations. The \( V \) values are very similar to the \( z \) values of the Normal Distribution. For the determination of the significance levels the following \( p \) values have been used: \( p < .05 \) for \( |V| \geq 1.96 \), \( p < .01 \) for \( |V| \geq 2.58 \) and \( p < .001 \) for \( |V| \geq 3.30 \). It follows that when the absolute value \( V \) is greater than 2, the difference is significant at a 5% level, and so on. When two percentages are compared a hypergeometric distribution is used to calculate the difference. When mean values are compared a t-test (student) distribution is used corrected for sampling without replacement (Lebart, Morineau & Piron, 1995).

From the analysis (Table 1), it has been concluded that gender is associated with the first and third factors. Boys expressed more positive views towards mathematics, compared to girls (Factor 1 - Mathematics Confidence (MC), \( V = 3.68 \)), and more positive views towards their confidence with technology, compared to girls (Factor 3 - Technology Confidence (TC), \( V = -5.13 \)). These results are in agreement with previous research studies (Pierce, Stacey & Barkatsas, 2007; Ruffell, Mason, & Allen, 1998; Fogarty, Cretchley, Harman, Ellerton, & Konki, 2001). Another finding of the study is that the Year 9 students expressed more positive attitudes compared to the Year 10 students, regarding their confidence with technology (Factor 3, Technology Confidence (TC), \( V = -2.59 \)).

Table 1
Factors by Supplementary Variables

<table>
<thead>
<tr>
<th>Categories</th>
<th>Number of students</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Year Level</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 10</td>
<td>536</td>
<td>-0,81</td>
</tr>
<tr>
<td>Year 9</td>
<td>557</td>
<td>0,81</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>549</td>
<td>3,68</td>
</tr>
<tr>
<td>Female</td>
<td>519</td>
<td>-3,78</td>
</tr>
<tr>
<td><strong>Mathematics Achievement</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E/F (&lt;50%)</td>
<td>96</td>
<td>-11,31</td>
</tr>
<tr>
<td>D (50-59%)</td>
<td>293</td>
<td>-13,59</td>
</tr>
<tr>
<td>C (60-69%)</td>
<td>319</td>
<td>0,44</td>
</tr>
<tr>
<td>B (70-79%)</td>
<td>278</td>
<td>14,26</td>
</tr>
<tr>
<td>A (80-100%)</td>
<td>98</td>
<td>9,75</td>
</tr>
</tbody>
</table>
CONCLUSIONS

The Multiple Correspondence Analysis resulted in two pairs of opposing categories, the first pair representing the following two opposing categories: students’ low levels of mathematics confidence, affective engagement and behavioural engagement in mathematics and students’ high levels of mathematics confidence, affective engagement and behavioural engagement in mathematics, and the second pair representing the following two opposing categories: students’ neutral levels of mathematics confidence, affective engagement and behavioural engagement in mathematics and students’ extremely high levels of mathematics confidence, affective engagement and behavioural engagement in mathematics.

High achievers in mathematics demonstrated high levels of mathematics confidence, strongly positive levels of affective engagement and behavioural engagement are not confident in using technology, appear to have a positive attitude to learning mathematics with technology.

Students with negative attitudes toward mathematics, low mathematics achievement, low levels of mathematics confidence and low levels of affective engagement and behavioural engagement, demonstrated confidence in using computers and positive attitude to learning mathematics with computers. Further research is required to identify the best teaching and learning environments for students in this category.

Another finding of the study is that the Year 9 students expressed more positive attitudes compared to the Year 10 students, regarding their confidence with technology (Factor 3, Technology Confidence (TC), V = -2.59).

Finally, one of the aims of the study was to explore gender differences (if any). Gender differences were found in the first and third factors. Boys expressed more positive views towards mathematics, compared to girls and more confident with technology, compared to girls. These results are in agreement with previous research studies (Pierce, Stacey & Barkatsas, 2007; Ruffell, Mason, & Allen, 1998; Fogarty, Cretchley, Harman, Ellerton, & Konki, 2001).

Overall, high-achieving boys - compared to girls - appeared to be more confident in mathematics, they demonstrated stronger behavioural and affective engagement, they were more confident in using computers and they demonstrated more positive attitudes to learning mathematics with computers.

REFERENCES


**ABSTRACT**

African Americans are greatly under-represented in careers in science, mathematics, engineering and technology (NSF, 2001) because of many cultural, societal, and/or school-based factors that impact on students both in school and out of school. This study evaluated the effectiveness of an innovative hands-on science program – Minority Aviation Education Association (MAEA) – on African-American middle-school students in Columbus, Ohio. MAEA is the largest science outreach company in the United States that was established and is operated by African Americans. The study investigated whether MAEA’s hands-on interactive science education techniques have a positive impact on African-American students’ learning environments, attitudes to science and achievement despite other factors influencing those students. The study’s data-collection methods were both qualitative and quantitative. The sample consisted of 250 middle-school students spread among an intervention school and two non-intervention schools.

**RESEARCH QUESTIONS**

Are questionnaires assessing classroom learning environments and students’ attitudes toward science valid and reliable when used with African-American eighth-grade students?

Are MAEA’s interactive science programs effective in terms of students’:

a) attitudes toward science  
b) science achievement  
c) perceptions of the science classroom learning environment?

Are there associations between the nature of the science classroom learning environment and students’:

a) attitudes toward science  
b) science achievement?

**BACKGROUND**

**Context of science education in the USA**

In the past, the United States was recognized as forging the lead in science, mathematics and technology but, recently, Asian and Indian countries have been the hot beds of innovation and technology. According to the 2003 Trends in International Mathematics and Science Study (TIMSS, 2003), United States eighth graders ranked 27th out of 34 countries in science. The United States ranked below Singapore, Chinese Taipei, Republic of Korea, Hong Kong, Japan, Hungry and the Netherlands. TIMSS results between 1995 and 2003 show that African-American eighth graders had larger improvements in their mathematics and science test results than did their white counterparts. However, on the 2005 NCES science tests, African-American eighth graders narrowed the gap but still scored 32 points below (124 vs. 160) the average score for white eighth graders (NCES, 2005a).

The lack of achievement among African Americans in mathematics and science is accompanied by a serious under-representation of African Americans in science, mathematics, engineering and technology-based careers in proportion to their 12% of the US population (US Census, 2000). Some of the key indicators of educational disparities are:

African Americans are only half as likely to complete a Bachelor’s degree as their white counterparts. African Americans make up approximately 12% of the population, but account for only 9% of all of the Bachelor’s, Masters and Doctoral degrees conferred by American institutions of higher education in the academic year 2002–2003 (NCES, 2005b). The average SAT score for African Americans in the United States is 857, while the overall average in America is 1026. The average wages for a high school dropout is $11,989 annually.
MAEA’s educational strategy

Minority Aviation Education Association Inc. (MAEA) was founded in 1992 to alleviate the under-representation of minorities and women in aviation and its related fields. The scope was widened to encompass all science, mathematics and related technologies for the same reasons of under-representation. MAEA uses a combination of relevant hands-on science and role modeling in an attempt to excite students about science, mathematics and technology, with the ultimate goal being to increase the minority workforce. According to Haury and Rillero (1994), students who experience hands-on teaching techniques tend to:

- remember and understand more of the material that they are taught.
- be more motivated to want to learn more.
- develop better communication, thinking, logic and decision-making skills.
- develop creativity.
- develop better attitudes toward science.

MAEA’s techniques for teaching science include using a mix of hands-on science activities and role modeling to promote lasting conceptual change. MAEA’s goal is to create conceptual change which enables students to see the big picture of how things work together from concepts to real-life applications (Pintrich, Marx & Boyle, 1993).

The central question in my study involved whether MAEA’s techniques of using hands-on activities in the science classroom are successful with inner-city middle-school students from the Columbus, Ohio school district in terms of their attitudes toward science, achievement and perceptions of their classroom learning environment. Furthermore, associations between the classroom learning environment and students’ attitudes and achievement were investigated.

Classroom learning environment

Since the pioneering research on Harvard Project Physics in the late 1960s (Walberg & Anderson, 1968), there have been many questionnaires developed to assess the classroom learning environment. These extensively-validated and widely-used instruments can be used to measure different aspects within the classroom learning environment (Fraser, 1998b). For example, some elements that can be evaluated include teacher-centered vs. student-centered classes, student participation level, group vs. individual learning and communication, teacher support, student input into assessment, and whether student interest or work speed are taken into account (Fraser, 2001).

This study drew on and contributed to the field of classroom learning environments (Aldridge, Fraser & Huang, 1999; Fraser, 1998a; Fraser & Walberg, 1991; Goh & Khine, 2002). In particular, it followed previous studies in which learning environment dimensions were used as criteria of effectiveness in evaluating an educational program (Maor & Fraser, 1996; Nix, Fraser, & Ledbetter, 2005).

Some of the fundamental questions that form the foci for classroom environment research include:

- Does a classroom’s environment affect student achievement and attitudes (Fraser, 1998a; McRobbie & Fraser, 1993)?
- Can teachers assess and change the environments of their own classrooms (Fraser, 1989; Fraser & Fisher, 1986)?
- Do teachers and their students perceive the same classroom environment similarly (Fisher & Fraser, 1983)?
- What is the impact of a new curriculum or teaching method on the classroom environment (Fraser, 1998a; Maor & Fraser, 1996; Nix, Fraser & Ledbetter, 2005)?
- What preferences do students have about their relationships with their teachers (Wubbels, 1993)?
- Do students of different abilities, genders or ethnic backgrounds perceive the same classroom environments differently (Fraser, 1986, 1989)?

RESEARCH DESIGN

The research design for this study involved pretest and posttest administrations of specific assessment tools. Also questionnaires were administered both in a school at which MAEA was implemented (experimental group) and at two other schools of similar demographics that were not undertaking MAEA hands-on programs (comparison group). The two questionnaires that were used were the What Is Happening In this Class? (WHIC) and the Test Of Science Related Attitudes (TOSRA). The WHIC and TOSRA were administered at the beginning of the school year and then again at the end of the school year.
Sample size

The subjects for this research were middle-school students from three schools in the Columbus public school district. The MAEA intervention school provided approximately 100 8th grade students and the two comparison schools provided another approximately 150 8th grade students. Students were from households of predominantly low socioeconomic status (SES) and schools located in low-SES neighborhoods. The students were overwhelmingly African American in their ethnicity. The schools were also chosen by the relative equivalence of their standardized test scores in past years.

What Is Happening In this Class? (WIHIC)

In order to assess classroom learning environment in our study, we selected the What Is Happening In this Class? (WIHIC) questionnaire because of the salience of its scales and its proven validity in prior research in numerous countries. The original version of the WIHIC consists of seven eight-item scales with a five-point frequency response format (Almost Never, Seldom, Sometimes, Often and Almost Always). Five of these WIHIC scales were selected for use in our study: Teacher Support, Involvement, Investigation, Task Orientation and Cooperation.

The sound factorial validity and internal consistency reliability of the WIHIC have been established in many past studies involving large samples: 1081 Australian and 1879 Taiwanese students (Aldridge, Fraser & Huang, 1999); 3980 students from Australia, the UK and Canada (Dorman, 2003); 661 American students (Ogbuehi & Fraser, 2007); and 1021 Indian students (Koul & Fisher, 2005).

Test of Science Related Attitudes (TOSRA)

We selected the Test of Science Related Attitudes (TOSRA, Fraser, 1981) for assessing students' attitudes in our study. The two scales that were chosen from TOSRA as being most relevant to our study were Attitude to Scientific Inquiry and Enjoyment of Science Lessons. We modified the original scales to reduce the scale length from 10 to 8 items, avoided confusing negatively-worded and reverse-scored items, and used the same frequency response alternatives as the WIHIC. The TOSRA has been widely used in past research and found to be valid and reliable (e.g., Fraser & Fisher, 1982; Wong & Fraser, 1996).

Achievement testing

To track the progress of its students throughout their years of education through the Ohio Department of Education (ODE), ODE established a series of periodic tests. The tests in science in Ohio are conducted in 5th and 8th grades, and there is a 12th grade exit examination. ODE contracted with the American Institutes for Research in Washington, DC, to develop and annually administer its K–8 testing program. The test is called the Ohio Achievement Test. In our study, students’ 8th grade science achievement test scores were compared with the results of other 8th grade students from the non-intervention school.

Interviews

Interviews were conducted both before and after instruction in the schools where the research was conducted. These interviews helped to establish how the students felt about their classroom learning environments and their teachers in their own words. Interviews are particularly useful for getting the story behind a participant's experiences and for obtaining in-depth information about a topic (McNamara, 1999). Interviews can be particularly useful in gathering opinions before and after introducing new teaching techniques or procedures (ERIC/Staff, 1997).

Ethical Considerations

The publication Practical Research reduces all ethical considerations to several main categories: conflict of interest; informed consent; protection from harm; right to privacy; and honesty with professional colleagues (Leedy & Ormerod, 2005). The research methods and procedures that we employed accommodated these ethical considerations.
RESULTS

Factorial validity of WIHIC

At the time of writing this paper, data collection and analysis are still ongoing. However, pretest administration of the WIHIC and TOSRA yielded 250 complete student responses that could be used to answer our first research question concerning the validity and reliability of these two questionnaires.

Table 1.
Factor Analysis Results for WIHIC

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Teacher Support</td>
</tr>
<tr>
<td>TS9</td>
<td>0.68</td>
</tr>
<tr>
<td>TS10</td>
<td>0.77</td>
</tr>
<tr>
<td>TS11</td>
<td>0.80</td>
</tr>
<tr>
<td>TS12</td>
<td>0.74</td>
</tr>
<tr>
<td>TS13</td>
<td>0.79</td>
</tr>
<tr>
<td>TS14</td>
<td>0.74</td>
</tr>
<tr>
<td>TS15</td>
<td>0.61</td>
</tr>
<tr>
<td>TS16</td>
<td>0.67</td>
</tr>
<tr>
<td>IN17</td>
<td>0.70</td>
</tr>
<tr>
<td>IN18</td>
<td>0.64</td>
</tr>
<tr>
<td>IN20</td>
<td>0.43</td>
</tr>
<tr>
<td>IN22</td>
<td>0.53</td>
</tr>
<tr>
<td>TO33</td>
<td>0.61</td>
</tr>
<tr>
<td>TO34</td>
<td>0.75</td>
</tr>
<tr>
<td>TO35</td>
<td>0.74</td>
</tr>
<tr>
<td>TO36</td>
<td>0.79</td>
</tr>
<tr>
<td>TO37</td>
<td>0.75</td>
</tr>
<tr>
<td>TO38</td>
<td>0.65</td>
</tr>
<tr>
<td>TO39</td>
<td>0.78</td>
</tr>
<tr>
<td>TO40</td>
<td>0.72</td>
</tr>
<tr>
<td>IV25</td>
<td></td>
</tr>
<tr>
<td>IV26</td>
<td></td>
</tr>
<tr>
<td>IV27</td>
<td></td>
</tr>
<tr>
<td>IV28</td>
<td></td>
</tr>
<tr>
<td>IV29</td>
<td></td>
</tr>
<tr>
<td>IV30</td>
<td></td>
</tr>
<tr>
<td>IV31</td>
<td></td>
</tr>
<tr>
<td>IV32</td>
<td></td>
</tr>
<tr>
<td>CO1</td>
<td></td>
</tr>
<tr>
<td>CO3</td>
<td></td>
</tr>
<tr>
<td>CO4</td>
<td></td>
</tr>
<tr>
<td>CO6</td>
<td></td>
</tr>
<tr>
<td>CO7</td>
<td></td>
</tr>
<tr>
<td>CO8</td>
<td></td>
</tr>
<tr>
<td>% Variance</td>
<td>15.31</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>11.70</td>
</tr>
</tbody>
</table>

N = 250

Items 2, 5, 19, 21, 23, 24 were omitted

Method: Principal axis factoring with varimax rotation and Kaiser normalisation.

Factor loadings smaller than 0.40 have been omitted.

To investigate the a priori structure of the WIHIC, the responses from the sample of 250 students to the WIHIC's 40 items were subjected to principal axis factor analysis with varimax rotation and Kaiser normalisation. The criteria for the retention of any item was that its factor loading must be at least 0.40 with its own scale and less than 0.40 with each of the other four WIHIC scales. The application of these criteria led to the elimination of four items from the Involvement scale and two items from the Cooperation scale.
Table 1 provides the factor analysis results for the WIHIC. After the removal of the six items, Table 1 shows that all of the 34 remaining items had a factor loading exceeding 0.40 with its own scale. Also all items had a factor loading of less than 0.40 with each of the other four WIHIC scales, with the exception of Item IN20 which also had a loading of 0.43 on Teacher Support, and Item IN22 which also had a loading of 0.41 on the Cooperation scale.

The bottom of Table 1 shows that the proportion of variance accounted for by different WIHIC scales ranged from 5.67% to 15.31%, with the total being 56.08%. The bottom of Table 1 also shows that the eigenvalue for different WIHIC scales ranged from 1.30 to 11.70.

**Internal Consistency Reliability of WIHIC**

The internal consistency reliability of each WIHIC scale was estimated for the sample of 250 students using Cronbach's alpha coefficient. Table 2 shows that the alpha reliability for different WIHIC scales ranged from 0.80 to 0.92.

Table 2.

*Internal Consistency Reliability (Cronbach Alpha Coefficient) for WIHIC Scales*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Number of Items</th>
<th>Alpha Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher Support</td>
<td>8</td>
<td>0.92</td>
</tr>
<tr>
<td>Involvement</td>
<td>4</td>
<td>0.83</td>
</tr>
<tr>
<td>Investigation</td>
<td>8</td>
<td>0.90</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>8</td>
<td>0.91</td>
</tr>
<tr>
<td>Cooperation</td>
<td>6</td>
<td>0.80</td>
</tr>
</tbody>
</table>

*N = 250*

**Factorial Validity and Internal Consistency Reliability of TOSRA**

As with the WIHIC data, the 250 students' responses to the 16 items of the TOSRA were subjected to principal axis factoring with varimax rotation and Kaiser normalisation. Table 3 shows that each of the 16 TOSRA items satisfied the two criteria of having a factor loading greater than 0.40 with its own scale and less than 0.40 with the other scale. The bottom of Table 3 shows that the two TOSRA scales accounted for 34.79% and 29.44% of variance, respectively, with the total being 64.23%. The eigenvalues shown at the bottom of Table 3 for the two TOSRA scales are, respectively, 6.98 and 4.00.
Table 3. Factor Analysis Results for TOSRA

<table>
<thead>
<tr>
<th>Item</th>
<th>Attitude to Scientific Inquiry</th>
<th>Enjoyment of Science Lessons</th>
</tr>
</thead>
<tbody>
<tr>
<td>INQ41</td>
<td>0.72</td>
<td></td>
</tr>
<tr>
<td>INQ42</td>
<td>0.74</td>
<td></td>
</tr>
<tr>
<td>INQ43</td>
<td>0.82</td>
<td></td>
</tr>
<tr>
<td>INQ44</td>
<td>0.75</td>
<td></td>
</tr>
<tr>
<td>INQ45</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>INQ46</td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>INQ47</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>INQ48</td>
<td>0.73</td>
<td></td>
</tr>
<tr>
<td>ENJ49</td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>ENJ50</td>
<td></td>
<td>0.83</td>
</tr>
<tr>
<td>ENJ51</td>
<td></td>
<td>0.85</td>
</tr>
<tr>
<td>ENJ52</td>
<td></td>
<td>0.86</td>
</tr>
<tr>
<td>ENJ53</td>
<td></td>
<td>0.87</td>
</tr>
<tr>
<td>ENJ54</td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td>ENJ55</td>
<td></td>
<td>0.78</td>
</tr>
<tr>
<td>ENJ56</td>
<td></td>
<td>0.84</td>
</tr>
<tr>
<td>% Variance</td>
<td>34.79</td>
<td>29.44</td>
</tr>
<tr>
<td>Eigenvalue</td>
<td>6.98</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Method: Principal axis factoring with varimax rotation and Kaiser normalisation. Factor loadings smaller than 0.40 have been omitted.

Table 4 shows that the internal consistency reliability (Cronbach alpha coefficient) for our sample was 0.92 for Attitude to Scientific Inquiry and 0.95 for Enjoyment of Science Lessons.

Table 4
Internal Consistency Reliability (Cronbach Alpha Reliability Coefficient) for TOSRA Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Number of Items</th>
<th>Alpha Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude to Scientific Inquiry</td>
<td>8</td>
<td>0.92</td>
</tr>
<tr>
<td>Enjoyment of Science</td>
<td>8</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Overall, the results reported in Tables 1–4 attest to the factorial validity and internal consistency reliability of both the WIHIC and TOSRA.

CONCLUSION

As a precursor to an evaluation of the hands-on science programs of the Minority Aviation Education Association (MAEA) among African-American middle-school students in low socioeconomic areas of Columbus, Ohio, we validated appropriate instruments. The sample consisted of 250 students. The instruments were the What Is Happening In this Class? (WIHIC) for assessing classroom learning environment and the Test of Science Related Attitudes (TOSRA). Various data analyses for this sample supported the sound factorial validity and internal consistency reliability of WIHIC and TOSRA scales.

Potentially there were motivational, operational and practical pitfalls associated with this research. A motivational limitation was the uncertainty about the ability of the science teachers to motivate their students. Another potential pitfall involved the influences that the students in the two groups encountered outside of school. Hopefully both positive and negative influences occurred for both intervention and non-intervention groups randomly and at the same intensity. However, any extreme influences that students encountered potentially could be identified during the interview process.

A limitation in terms of the generalizability and applicability of the research results arises from the relatively small and homogeneous sample. There also could be a problem if students left or changed schools during the school year or opted out of the research entirely. Another practical pitfall was the similarity of the schools in the
sample. It could be argued that the results from this study strictly are only applicable to schools with a demographic make-up similar to the schools in our sample.

The standardized test for middle-school students in Ohio is only given at the eighth-grade level. This made it impossible to track changes in students’ standardized test scores. Another operational pitfall resided in the school district itself. MAEA brought in necessary equipment and supplies to provide hands-on science for the students. If the school district wanted to replicate the same type of experiences for all of its students, it could encounter a substantial cost outlay for the purchase of the needed materials. The material demands associated with implementing the techniques used in this study also could limit the study’s generalizability.

This research has the potential to be practically significant because it could demonstrate how Columbus public schools could improve the learning environment and learning outcomes (achievement and attitudes) for their African-American middle-school students. These same methods could be used by many other inner-city school districts around the country to promote similar changes. Also, in today’s world of high-stakes testing, the research could suggest how school districts could improve the standardized test scores in science among its middle-school students.

Any links between students’ achievement or attitudes in science and their perceptions of the classroom learning environment could be used by educators to guide improvements in students' outcomes.

This study is distinctive within the field of learning environments because of its focus on African-American students and because it provided the first rigorous evaluation of MEAE.

REFERENCES


Fraser, B.J. (2001). Twenty thousand hours. Learning Environments Research, 4, 1-5.


AN ANALYSIS OF SECONDARY SCHOOL STUDENTS’ PERCEPTION OF MATHEMATICS AND
MATHEMATICIANS IN A DEVELOPING COUNTRY

Hemant Bessoondyal

ABSTRACT

The purpose of this paper is to analyse the perception of secondary students in Mauritius towards mathematics and mathematicians in view of determining their attitude towards the subject. The Draw-A-Mathematician-Test was used with a sample of 81 secondary school students who were asked to draw what they perceive to be a mathematician. Interviews were also conducted with them to discuss further their ideas and what typical work a mathematician is normally engaged in. The results show many characteristics depicted in studies conducted in other countries were found in their drawings. Many students in the sample had the image of their mathematics teacher as a mathematician. Furthermore, only eight students out of the 81 students in the sample drew female mathematicians; seven being girls and one a boy. This observation reinforced the idea that students perceive mathematics to be a masculine activity. Another important finding is that many students showed mathematicians as incompetent or having supernatural powers. These results suggest that these students had a negative attitude towards mathematics and doubted their ability to do well in mathematics. Teachers need to be aware of the students’ perceptions concerning mathematicians and mathematics so that they can devise ways and means to help students develop appropriate images of the subject. This will consequently motivate students to learn mathematics and help in the teaching and learning process.

INTRODUCTION

Mathematics plays a fundamental role in the life of human beings. It promotes logical and rational thinking and enhances one's ability to analyze and to solve problems. Mathematics has been seen to act as a 'critical filter' in the social, economic and professional development of individuals. Mauritius relies, to a great extent, on its human resource power to meet the challenges of the technological developments and a substantial core of mathematics is needed to prepare students for their involvements in these challenges. An analysis of the performance in mathematics at both CPE and SC level in Mauritius has revealed that there is a significant percentage of students who do not perform as well as expected in the subject (Bessoondyal & Malone, 2005) and consequently face difficulties in pursuing further studies or move up the economic and social ladder. Research (Khalid, 2004; Schiefele & Csikszentmihalyi, 1995) have shown that one way to bring about changes in the teaching and learning of mathematics is to arouse the interest of the students in the subject and motivate them towards their learning. Several studies have shown that interests influence academic achievement and learning in school (Krapp, 1998a, 1998b, 1999; Schiefele, Krapp & Winteler, 1992; cited in Köller, Baumert, & Schnabel, 2001) On the other hand, in a recent study, Ma and Xu (2004, p. 275) have shown that “the causal ordering between attitude toward mathematics and achievement in mathematics is predominantly unidirectional from achievement to attitude across the entire secondary school”. A brief description of the country where the research was carried out together with the educational system is discussed in the next section.

BACKGROUND

Mauritius is the main island of the Republic of Mauritius which consists of a number of small islands in the Indian Ocean scattered within a radius of 800 kilometres. The other islands are Rodrigues and Agalega. Mauritius covers an area of 1860 square kilometres and is approximately 800 kilometres from Madagascar and 2500 kilometres from Durban, South Africa. The island has no indigenous population and all the inhabitants are descendants of immigrants from different parts of the world. According to the Constitution of Mauritius, the population is composed of Hindu, Muslim, Chinese, and the General Population. There are a variety of languages in the islands: English, French, Creole, Mandarin, Hindi, Tamil, Telegu, Marathi, Urdu, and Bhojpuri.

The education system in Mauritius follows a British pattern with a three-stage model: 6+5+2 – that is, 6 years in primary (Standard I – Standard VI) leading to the Certificate of Primary Education (CPE); 5 years (Form I – Form V) in secondary school leading to the Cambridge School Certificate (SC); and 2 more years (Lower VI and Upper VI) in secondary school leading to the Higher School Certificate (HSC). Education is free in Mauritius from the primary to tertiary levels. Primary education has been made compulsory since 1993, secondary education made free
since 1977, and tertiary education is free at the University of Mauritius (except for a nominal fee concerning registration and stationery). There are some courses at the masters level that are fee paying. Also, some fee-paying institutions exist at the primary, secondary and tertiary levels.

The diagram below shows the formal educational system in Mauritius.

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard I to VI</td>
<td>Form I to VI₂</td>
</tr>
<tr>
<td>I</td>
<td>II</td>
</tr>
<tr>
<td>5+</td>
<td>11+</td>
</tr>
</tbody>
</table>

CPE - Certificate of Primary Education  
SC - Cambridge School Certificate  
HSC - Cambridge Higher School Certificate  
VI₁ - Six One (Lower Six or first year HSC)  
VI₂ - Six Two (Upper six or second year HSC)

The sample chosen for this study is Form IV students (of average age 15). It is at this level that students choose their stream of study (Science, Arts or Technical) and their options. Due to its importance (as described above), mathematics is chosen by all students at this level. To get an idea of the perception that students have of mathematics and of a mathematician, the Draw- A- Mathematician-Test (Picker & Berry, 2000) was used.

**Draw-a Mathematician-Test**

A lot of studies have been conducted in relation to the use of the Draw- A- Scientist-Test (DAST) to analyse the perception of students concerning Science and Scientists (Bessoondyal & Gribble, 2003). Inspired by the work of Chambers and others concerning DAST, researchers have tried to find out the perception of students concerning a mathematician. Furringhetti (1993) rightly points out that mathematics “is a discipline that enjoys a peculiar property: it may be loved or hated, understood or misunderstood, but everybody has some mental image of it” (cited in Picker & Berry, 2000, p 65). The perception that children hold concerning mathematics and mathematicians is extremely important to be known to enable the teaching and learning of mathematics to be done efficiently. In fact Lim & Ernest (1999) emphasize that one should first ascertain how popular or unpopular mathematics is to be able to find measures to change and improve its public image (cited in Picker & Berry, 2000). The following comments by Lim and Ernest are worth heeding.

“it is a matter of great concern that … negative images of mathematics might be one of the factors that has lead to the decrease in student enrolment in mathematics and science at institutions of higher education, in the past decade or two… the term ‘image of mathematics’ refers to a mental picture, view or attitude towards mathematics, presumably developed as a result of social experiences, through school,, parents, peers, mass media or other influences.”  
(cited in Berry & Picker, 2000, p2)

A report by the National Research Council (1999) made the following comments concerning the state of the image of mathematics held by pupils:

“Unfortunately, as children become socialized by schools and society, they begin to view mathematics as a rigid system of externally dictated rules governed by standards of accuracy, speed and memory. Their view of mathematics shifts gradually from enthusiasm to apprehension, from confidence to fear. Eventually, most students leave mathematics under duress, convinced that only geniuses can learn it”  
(cited in Picker & Berry, 2000, p 67)
METHODOLOGY

This research is part of a larger study conducted for a doctoral degree. The first phase of the study consisted of administering a problem solving questionnaire, along with a second questionnaire focusing on the attitude of students to mathematics, to a sample of students of Form Four chosen from seventeen secondary schools. The analysis of these questionnaires confirmed that students in Mauritius lack conceptual understanding in mathematics and face problems while solving non-routine questions (Bessoondyal & Malone, 2005). In the second phase, a case study approach was used. A representative sample of four schools was chosen: one single-boys school, one single-girls school, and two coeducational schools. A class of Form Four in each of the schools was then chosen and the questionnaires were administered. After analyzing data collected through the questionnaires, appropriate issues were identified to be probed further during interviews with the students. With a view to obtain the perception of the students towards mathematics and mathematicians, the Draw-A-Mathematician-Test (Picker & Berry, 2000) was administered to all the students involved in this sample. Each student in the classes chosen for the second phase of the study was asked to draw a mathematician at work, explain their drawings and provide further clarifications about their images. They had also to give three reasons why one would need the services of a mathematician. Through this activity the intrinsic attitude and perception of the student towards mathematics could be determined which in some way or the other could have been influencing their response and engagement towards mathematical activities.

FINDINGS AND DISCUSSIONS

Out of 118 students who were involved in this phase of the study, 81 submitted their drawings of a mathematician. The drawings made by the Mauritian students had many of the characteristics depicted in various studies conducted abroad, such as the recent work of Sumida (2002) in China, Indonesia, Korea, the Philippines, and Japan. The Mauritian students' drawings were assessed using the standard basic indicators (Kahle, 1989) in DAST (relevant to a mathematician) and some others drawn from the work of Picker and Berry (2000). The results are shown in Table 1 below.

Table 1
Number of Boys and Girls Who Drew Stereotypical Indicators in their Drawings

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glasses</td>
<td>35</td>
</tr>
<tr>
<td>Facial hair</td>
<td>19</td>
</tr>
<tr>
<td>Symbols of research</td>
<td>7</td>
</tr>
<tr>
<td>(e.g. mathematical instruments)</td>
<td></td>
</tr>
<tr>
<td>Symbols of knowledge</td>
<td>22</td>
</tr>
<tr>
<td>(e.g. books)</td>
<td></td>
</tr>
<tr>
<td>Mathematical formulae</td>
<td>9</td>
</tr>
<tr>
<td>Beard</td>
<td>29</td>
</tr>
<tr>
<td>Bald</td>
<td>7</td>
</tr>
<tr>
<td>Calculator</td>
<td>1</td>
</tr>
</tbody>
</table>

It should be noted that only eight students out of the 81 students in the sample drew female mathematicians; seven being girls and one a boy. This observation reinforced the idea that students perceive mathematics to be a masculine activity. Furthermore, many students (49 in all) tended to imagine their teacher when they created their drawings. An example is illustrated in Figure 1.
Figure 1: Mathematician as a teacher.

Very often the formulae that were represented in students' drawings were those found on classroom blackboards, or on papers lying on the teachers' table, or were those that students were actually working with in classroom activities. It also was significant that the mathematical scribbling in the drawings ranged from simple mathematics (like $1+2=3$) to meaningless writings involving mathematical symbols and operations. It was found that 14 students drew mathematicians as queer persons. An example of this is shown in Figure 2.
In many cases the writings which accompanied the drawings give an insight to what the student thought about what mathematics is all about. A sample of the writings follows:

- “Always angry, serious and in bad mood, hot tempered”
- “A mathematician looks very boring”
- “A mathematician becomes old very quickly because everywhere they go they want to do some calculation”
- “In my point of view the portrait a mathematician should be like this; that is by his appearance he should look wise and clever. He should be serious. He should look sophisticated and have a philosophical mind so that he can think in order to create maths formula”
- ‘Stupid fellow”
- “My brain is a computer”
- “I will become mad if I continue to learn maths”
- “Wrinkles due to mathematical stress”
- “When a mathematics teacher has no hair on his head this means that he studies very hard to achieve something”

Importantly, no drawing by any students in the Mauritian sample depicted a student or younger person. Picker and Berry (2000) reported that the drawings by students in almost every country chosen for their study showed any students drawn as small and powerless. In contrast, mathematicians were drawn as authoritarian and threatening.

When students were questioned about hiring the services of a mathematician, many answered that they would do this because it would help them in solving problems and force them to learn mathematics. The image of a mathematician as a personal tutor to help with or to solve complicated problems in mathematics can be found throughout the drawings and discussions with the students in this Mauritian study. It was revealed in the study that for students of this age, mathematicians in real world situations are too far removed from their imagination. The students relied on their teacher or stereotypical images from the media to provide images of mathematicians for the drawings produced in the study.

It was found throughout the drawing exercise that most students held a stereotyped image of mathematicians and mathematics. The drawings showed the mathematician as incompetent or having supernatural powers which suggested that the students had a negative attitude towards the subject or doubted their abilities in doing mathematics. These attitudes may be related to the invisibility of the mathematical processes in students’ learning activities. The issue here is that when mathematical processes are not explicitly apparent for students, mathematics
competence looks more like an external power, outside the real world of the student, rather than an ability which everyone has the potential to develop. It appeared that Mauritian students are influenced by their teacher role models and hold a very masculine image of the subject. It is a worrying indictment on mathematics in the school curriculum when students believe that learning mathematics has no benefits for them. One student (girl) wrote in her drawing:

- “I think that mathematicians are needed to add problems to the lives of we people. They complicate our lives with their difficult formulae”

At the same time there were a number of positive comments such as:

- “We need the services of a mathematician as he is someone who has a very high mental faculty and uses it to invent formulae and theorems which are later used so as to make the students develop their sense of reasoning”.

CONCLUSION

This paper describes a study where the use of imagery has helped in eliciting students' perceptions of mathematicians and mathematics. The drawings made by the children, small comments put in their drawings and reasons that they put forward to justify the services of a mathematician provide an important insight of the picture that the subject has in the mind of the student. For instance, the drawing illustrated in Fig.2 tends to show that this student sees a person involved in doing mathematics as carrying out strange activities, with extra powers (my brain is a computer) and which needs a lot of effort and hard work (I will become mad if continue to do mathematics). It also seems that that child is describing his/her teacher, as it is shown that the teacher is giving the page numbers for homework. At the same time the teacher is uttering the words “stupid fellow”. This suggests that the student who has made this drawing found his/her teacher to be frequently using admonishing words. Many interpretations of these kinds can be made from the drawings made by the students. The results of the study also showed that many characteristics depicted in studies conducted in other countries were found in the students’ drawings. Teachers should be aware of the perceptions students hold concerning mathematics and mathematicians and devise ways and means to help them develop appropriate images of the subject. Such a positive attitude will definitely enhance the liking for and the teaching and learning of the subject.

REFERENCES


ABSTRACT

The Australian Education Council (AEC) reached agreement in 1989 on 10 goals for education. There were eight common learning areas with science being one of them. The Curriculum Corporation was established to develop curriculum framework statements and the National Statements and Profiles that provided a curriculum framework providing the potential for significant change in the direction of Science Education in Australia. In 1994, a two-year ‘Key Teacher in Science Program’ for implementing the National Statements and Profiles was introduced to Tasmanian state schools (Tasmania being the southernmost of the Australian states). The Key Teacher in Science Program was a major strategy for professional development for teaching in the Science Learning Area in Tasmania, and was the Tasmanian response to the National Statements and Profiles. This paper discusses the effectiveness of the Key Teacher in Science Program, and makes further recommendations for developing Science Education. This is particularly pertinent as the Australian Federal Government gives evidence of moving toward greater centralisation, over state issues including education. There is a renewed interest in developing a national curriculum in science in Australia and hence benefit can be gained from a review of the experiences arising from past initiatives.

BACKGROUND

In 1989 the Ministers of Education from all states of the Commonwealth along with their Federal counterpart met in Hobart as the 60th Australian Educational Council (AEC) (MCEETYA Secretariat, no date). There they developed a set of Common and Agreed National Goals for Schooling (known as ‘the Hobart Declaration on Schooling’), which, among other things, involved the beginning of a national collaboration in curriculum development and the establishment of the Curriculum Corporation of Australia. It was the latter organization that developed the National Statements and Profiles that became a part of the guidelines by which individual state Ministries of Education developed state science curricula. In 1994, the Tasmanian Ministry of Education introduced a collaborative process for changing science syllabi entitled ‘The Key Teacher in Science Program’. The AEC has since been subsumed into the Ministerial Council on Education, Employment, Training and Youth Affairs (MCEETYA).

I was a participant in the Key teacher in Science Program in 1994, and considered it to be a very useful experience due to the time made available for discussion, teamwork, collaboration with colleagues, and renewal of enthusiasm for teaching. Far too often innovations in education are thought to be excellent by the participants, but often too few records of the experiences are created. I decided that, as this was a positive experience for me and appeared to be so for others, I would describe and review the program. This paper is part of a larger study by Beswick (2007).

DISCUSSION

In commenting on the Science Statement that arose out of the Curriculum Corporation’s work, Malcolm (1993) suggested that it promoted approaches in science that were constructivist in nature, in that they inclusive and took students’ backgrounds and interests into account. In addition to the traditional emphasis on scientific theories, the applications and contexts of science and scientific work were included. The Science Profile was a Year 1 – 10 document and was to be used as an aid to program planning, teaching and assessment. Malcolm summarized the suggested curricula structure in table form, the essence of which is shown in Table 1. Its emphasis was such that it encouraged teachers to work not only with student groups, but also with individual students. Students were to be assessed at Levels 1 – 8, with Level 8 indicating work of significant quality. Assessment and reporting procedures were designed to provided information about individuals, levels, schools, and school systems.
Table 1

*Strands and Sub-strands of the Australian Science Profile*

<table>
<thead>
<tr>
<th>Strand</th>
<th>Sub-strand</th>
<th>Branch of science covered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working scientifically</td>
<td>Planning investigations</td>
<td>Working Scientifically</td>
</tr>
<tr>
<td></td>
<td>Conducting investigations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Processing information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluating findings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Using science and acting responsibly</td>
<td></td>
</tr>
<tr>
<td>Earth and beyond</td>
<td>Earth, sky and people</td>
<td>Earth and Space Sciences</td>
</tr>
<tr>
<td></td>
<td>The changing earth</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Our place in space</td>
<td></td>
</tr>
<tr>
<td>Energy and Change</td>
<td>Energy and us</td>
<td>Physics</td>
</tr>
<tr>
<td></td>
<td>Transferring energy</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Energy sources and receivers</td>
<td></td>
</tr>
<tr>
<td>Life and Living</td>
<td>Living together</td>
<td>Biological Sciences</td>
</tr>
<tr>
<td></td>
<td>Structure and function</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Biodiversity, change and continuity</td>
<td></td>
</tr>
<tr>
<td>Natural and Processed materials</td>
<td>Materials and their uses</td>
<td>Chemistry</td>
</tr>
<tr>
<td></td>
<td>Structure and properties</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reactions and change</td>
<td></td>
</tr>
</tbody>
</table>

Table modified from the table developed by Malcolm (1993, p. 2)

Mann (1994) reported that Tasmania decided that an early focus area was to be the Science statements and profiles. Tasmania, South Australia and Western Australia designated teams of consultancy support to provide training and development support for teachers.

A 1993 joint submission for National Professional Development funds was made on behalf of the Tasmanian Department of Education & the Arts (DEA), University of Tasmania, Tasmanian Educational Consortium Ltd., and the Centre for Precision Technology, for a Collaborative Curriculum Key Teacher Training Program. The target was training programs for teachers in schools with responsibilities for implementing national Curriculum Statements and Profiles (Tasmanian Department of Education & The Arts, 1993).

In the rationale for the project it was stated that in Tasmania, since 1990 there had been a move to school self-management, and the beginning of implementation of the national collaborative curriculum statements and profiles. This had “reinforced the need for systematic and thorough professional learning opportunities for teachers at all levels of the state teaching service” (Tasmanian Department of Education & The Arts, 1993, p. 1). It was stated that curriculum initiatives depend on the availability of targeted funding, and that “with the withdrawal of special funds, initiatives rapidly disappear both at the system level and the school level” (Tasmanian Department of Education & The Arts, 1993, p. 1). The Department’s goal for the project was “to enhance existing initiatives for the implementation of curriculum statements and profiles within a framework which will be sustainable from Departmental resources at the conclusion of this Commonwealth initiative” (Tasmanian Department of Education & The Arts, 1993, p. 1).

“During 1992, the Tasmanian Department of Education and the Arts initiated local professional development support structures to be used for the implementation of national collaborative curriculum statements and profiles as well as other initiatives. This support structure was “known locally as the Key Teacher Team” (Tasmanian Department of Education & The Arts, 1993, p. 2). The 1993 proposal aimed to provide specialist training and ongoing support for Key Teachers, in several learning areas, with Science being one of them.

The Key Teachers were to be selected from within the staff of the school. The criteria for selection were that they: were experienced teachers; were well qualified; had a commitment to professional growth; had a strong interest in their chosen field; were highly regarded by other teachers in the school; and were strongly supported by the Principal, and senior staff so they could operate effectively within the school.
The roles of the Key Teachers in Science were:

- To lead school-based workshops in the Science area. Funding would provide for resources and professional development, together with the opportunity to participate in a network of Key Teachers.
- To facilitate teacher collaboration involving groups of teachers working together on developing curriculum materials, planning their teaching, and reflecting upon and evaluating their work. The Key Teacher was also to model teaching strategies and establish and maintain a strong focus on the Science learning area.
- To facilitate discussion on the curriculum, teaching methods and resources and help the school plan for change.

The schools were required to accept some responsibilities in relation to Key Teachers (Tasmanian Department of Education & The Arts, 1993, pp. 3 – 4). These were to:

- provide adequate relief and support materials;
- free the Key Teacher on a regular, timetabled basis during the year;
- ensure the Key Teacher was not overloaded with other school responsibilities;
- ensure that, if the Key Teacher was not in a senior position that he or she had a mentor in a position of authority;
- provide the Key Teacher with opportunities to speak with teachers about their roles and the program at staff meetings;
- provide the Key Teacher with opportunities to discuss their program with senior staff at regular intervals;
- encourage and provide practical support to teachers working with the Key Teacher;
- enable Key Teachers to attend regular network meetings.

It was planned that participants in the Key Teacher in Science Program would collaborate in discussing and evaluating current theories of learning and teaching in order to establish an on-going process that would:

- structure course content related to developing cross-curriculum initiatives in implementing profiles;
- plan whole-school curriculum involving the profiles;
- implement key ideas from the national profiles in Science;
- develop science materials to support implementation of profiles;
- connect profiles with systemic initiatives;
- monitoring and assessing the process.

(Tasmanian Department of Education & The Arts, 1994).

It was proposed that 40 Key Teachers would be involved in the Science program in 1994 and that this would grow to 110 by 1995. Over the three years 1994 – 96 it was intended that 510 teachers would have participated in the various Key Teacher Programs.

The 1993 submission requested Commonwealth funding of $502,800, to support Key Teachers in Science plus four other learning areas in 1994. This was to be supported by a school commitment of $1.4 million. This was to be provided from school resources. Further, the document stated that “from 1994 schools will be asked to include in their school plan an annual allocation of resources equivalent to two (2) days for each member of staff to be used for the implementation of national curriculum statements and profiles” (Tasmanian Department of Education & The Arts, 1993, p. 12).

The DEA’s National Professional Development Program (NPDP) accountability statement in August 1994 stated that a five-day training program was planned for Key Teachers in Science in October for 42 participants. The course was to be facilitated by officers of the DEA, and the Tasmanian Educational Consortium Ltd (TECL). A summary of the details of the training program is shown in Table 2.
Table 2

A Summary of the Five-day Training Program Planned for Key Teachers in Science

<table>
<thead>
<tr>
<th>The Science Statement and Profile</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Statement</strong> (purpose, underpinning assumptions about science and science education, beliefs about what science education should be achieving, unifying ideas)</td>
</tr>
<tr>
<td><strong>Profile</strong> (purpose, underpinning assumptions about the nature of learning and notions of progression, complexity, coherence, levels, judging and describing learning using the profile)</td>
</tr>
</tbody>
</table>

**Current views of learning**
The nature of knowledge and the nature of learning particularly from the point of view of constructivist theory.
Children’s ideas about science – what the research indicates.

**Approaches to Teaching**
Generative approach, Interactive approach, classroom communities of inquiry, inclusive teaching, literacy and science teaching, relating science, society and technology.

**Using the science Statement and Profile**
Personal planning, assessing learning, School planning (extending science education in your school, theories of implementing change, leading professional learning, establishing a professional learning culture in schools, whole school curriculum planning).

**Working together** as a District team and establishing on-going structure for discussion and support. (Tasmanian Department of Education & The Arts, 1994)

**METHOD**

Permission was obtained from the Tasmanian Department of Education, Community and Cultural Development to conduct research into the response of the Tasmanian Education department to the Hobart declaration in relation to Science Education in Tasmanian Schools.

A survey form was developed to obtain information from the participants in the Key Teacher in Science program. Information was sought about the background of the teacher, comments about the Key Teacher in Science Program, school changes, professional development, and the perceived future needs in the science learning area. The same questions, with different codes, were asked of curriculum officers who participated in the program in addition to acting as facilitators. Teachers were advised that the information sought would be confidential.

The surveys were posted to participants at their school in early November 1996, together with letters to the school principal and to the individual teachers. A period of about two weeks was assigned for the completion of the surveys. Follow-up was conducted in early December by phone and fax. Teachers who were from kindergarten to grade 6 were classified as primary teachers, and teachers from high schools, district high schools and colleges were classified as secondary teachers.

Participants in the program were resurveyed towards the end of 1998. The objective was to identify whether or not the perceptions of participants in the program had changed since their initial involvement. It was now 4 and 5 years after their participation and it was thought useful to be able to assess the longer term influences, and if the satisfaction level remained as high as it was initially.

The aim was to establish if the initial positive impressions of the success of the Key Teacher in Science Program were sustained over time. This would help to establish the viability of similar programs being conducted in the future. Survey results for 1996 and 1998 were compared.

The questions asked in 1998, were the same as those asked in the 1996 survey, with the addition of further questions in the section on Professional Development. As the Key Teacher in Science Program was a major strategy for professional development in the Science Learning Area in Tasmania, and the implementation of a Federally endorsed science curriculum, it was decided that it would be beneficial to ask additional questions about its impact.

This part of the survey was divided into the following three sections.

Section 1 was based on interview questions used in a 1983-85 evaluation of professional development practice in Tasmanian schools conducted by Docker, Fisher and Hughes (1985). These questions were now related to the science learning area by the researcher.

Section 2 used questions that were asked by Crowther and Gaffney (1993) of 34 focus groups, encompassing all the states and territories, which explored the perceptions of a representative group of primary and secondary
teachers prior to a number of initiatives, such as the NPDP program, to assist Australian teachers in implementing national priorities in education. These questions were now asked in a survey format and not in the focus group method as in the 1993 study.

Section 3 of the survey encompassed professional development and utilized the same questions as in the 1996 Key Teacher in Science survey instrument.

A study of the effectiveness of the Key Teacher in Science Program of professional development which was a means of facilitating curriculum implementation, would, I felt, not be complete without obtaining the opinions of, and attitude to, the science courses offered at both primary and secondary schools by those whose lives will be most affected; the students. Additional information was obtained from parents and students (322 completing a survey), from five different types of schools which added to the body of knowledge, and assisted in the formulation of recommendations.

SUMMARY OF RESULTS

Survey results 1996

The Key Teacher in Science Program was considered to be very successful by its participants. 84% of teachers recommended that similar programs be offered in the future, with the additional 15% saying that it should be offered ‘in part’. None of the respondents indicated that the program was not worthwhile.

Professional development was considered to be enhanced by being able to work with others, acquiring knowledge of educational philosophy and teaching strategies. There was an increased level of confidence in the teaching of science reported by primary teachers.

Both primary and secondary teachers indicated that they would like to participate in additional professional development in teaching and learning. Secondary teachers expressed a wish for more professional development in assessment and reporting, and primary teachers’ professional development in learning areas other than science, which is a reflection of their need to be able to teach in a range of learning areas.

Secondary teachers were concerned about a future paucity in the supply of qualified and experienced teachers of science; an issue discussed within the Harris, Jensz and Baldwin (2005) report. Secondary teachers also indicated that science should be maintained as a discrete subject within the school curriculum, and that all students have a right to have quality science teaching and learning.

Primary teachers noted that an expanding curriculum placed demands on time and that servicing other learning areas made it difficult to give sufficient time in order to adequately teach science within the primary classroom.

Secondary teachers noted that changes resulting from the Key Teacher in Science Program in rank order included:

- curriculum development;
- increased knowledge of learning styles and teaching strategies by participants;
- modifications made to assessment and reporting within a school.

Primary teachers noted that changes in primary schools, in rank order included:

- curriculum development;
- the provision of resources;
- an increase in the profile of science;
- increased knowledge among teachers of learning styles and teaching strategies;
- an increased knowledge among teachers of the science statement and profile.

Facilitators of change in the science learning area following teacher involvement in the Key Teacher in Science Program included:

- the support of the principal or other senior staff in a school;
- the support of other staff;
- the provision of money;
- the provision of time;
- professional development.
The lack of support or provision of these factors acted as hindrances to change. For example, many respondents listed a lack of money, time or the interference of other school priorities, and staffing issues (such as staff transfer, changing roles, and resistance of other staff members) as providing difficulties to the process.

It was therefore considered that the Key Teacher in Science Program was worthwhile and of a format that should be continued. The contacts made with colleagues were seen as strength of the program. All too often teachers tend to become isolated within their individual school communities and do not benefit from professional dialogue with their peers in other schools.

The professional development of teachers of Science, and their qualifications are crucial to delivering an appropriate Science curriculum to students, and ensuring that they are provided with a *Science Education* that will ensure that all the factors crucial for economic, technological, and social development of Australia together with achieving a scientifically literate community are met.

**Survey results 1998**

In the 1998 Key Teacher in Science Survey 64% of respondents recommended that similar programs be offered in the future, with an additional 32% saying that it should be offered ‘in part’; which compared with 84% and 15% in 1996. Teachers still found the program to be successful after a time lag. The importance of the Key Teacher in Science Program of professional development, in providing the opportunity to share ideas was also supported by a New Zealand study (New Zealand Ministry of Education, 2003).

**RECOMMENDATIONS**

The recommendations made relate to the professional development of science teachers, science curriculum and science teaching. Many of them could also be applicable to other curriculum areas. They have been informed by a literature review and the study by Beswick (2007), of which parts have been outlined in this paper.

1. The community needs to understand the value of science by gaining an understanding of its necessity for Australia’s economic, technological and social development, through the creation of a scientifically literate community.
2. More students would be engaged and interested in science if they were taught by well qualified, enthusiastic teachers with a passion for their subject.
3. Students like their teachers to possess good classroom management and organisational skills.
4. Schools need to be provided with the resources to conduct a science program – equipment and materials.
5. The nature of the science curriculum which appeals to students is determined by their developmental level, which needs to be taken into account in developing curriculum.
6. The applications of science and career pathways need to be highlighted to students.
7. Students and parents would like clear reports indicating what students have performed well at, and what they need to improve.
8. Teachers need to be provided with time to adjust to new initiatives in curriculum. In addition time is needed for discussion with colleagues within a teacher’s school, and within a cluster.
9. New curriculum initiatives need to be provided with sufficient resources for professional learning of teachers to occur, which needs to be ongoing.
10. A national curriculum in the science area rather that national consistency of outcomes would result in greater efficiencies in the development of teaching resources, professional development programs and assessment tools.
11. Schools and science teachers, in particular, need to make sure that their educational intentions in their teaching and learning programs are understood by their students.
12. The school community (particularly students and parents) need to be informed about teaching and assessment programs and provided with information about new directions.
13. Scholarships should be given to our most talented science students to pursue careers in teaching.
14. To ensure that we have qualified science teachers in classroom, we need to ensure that they are appropriately rewarded for their efforts. A highly qualified teacher should have a pay scale which reflects this.
15. Teachers should be able to be rewarded for ‘good teaching’ without having to be promoted to a non-teaching position to gain further advancement in the education system.
16. Teachers identify the provision of time in which changes can be made as an important characteristic of good professional development.
17. Good professional development of science teachers enables them to keep up to date with new developments in science, resulting in a rich curriculum, and maximises the skills and career opportunities of students.
18. Qualified science teachers could be retained within the teaching profession, by valuing their skills and rewarding them accordingly.
19. Experienced science teachers should be encouraged to continue to teach past ‘retirement’ age, as they have expertise and experience which is difficult to replace.
20. Experienced science teachers should act as mentors of new teachers. Both groups of teachers should be allocated a reduced teaching load for this purpose, to allow time for planning and discussion.
21. The Key Teacher in Science Program as a model of professional development was effective in its aims and should be used as model for the implementation of future science curriculum initiatives.

CONCLUSION

The Key Teacher in Science Program was a Tasmanian professional development program developed in response to a national curriculum initiative. It highlights the importance of continuing a focussed professional development program for teachers which will result in a high quality science education program.

REFERENCES

Tasmanian Department of Education & The Arts. (1993). *National professional development program: Submission on behalf of the Tasmanian Department of Education & The Arts*. University of Tasmania, Tasmanian Educational Consortium Ltd., & Centre for Precision Technology.
Tasmanian Department of Education & The Arts. (1994). *National professional development program accountability statement*. 

69
SURVEY INSTRUMENTATION, DEVELOPMENT, TRIALLING, IMPLEMENTATION AND EVALUATION

Greg Calvert
Elizabeth College, Australia

ABSTRACT

This paper considers the procedures undertaken for the development of a survey instrument aimed at gathering data on international fee-paying students studying Science and Engineering in Australia, and the link between their course and intended future career. As the survey was primarily aimed at a student population whose first language was not English considerable time was spent on trialling and evaluating the survey. The survey was implemented to students studying across a number of educational sectors (Higher Education, Vocational Education and Training and Schools). The varying levels of education being studied by the students imposed a further complexity on the development and implementation of the survey. The paper outlines the procedures undertaken to develop and implement a survey in addressing the challenges presented by gathering meaningful data from a culturally diverse target sample.

PURPOSE OF THE STUDY

This paper considers the use of the collection of data (2003 – 2005) relating to international fee-paying students studying Science and Engineering in Australia. The study examined the link between a student’s course and their intended future career. A particular aspect of the study was measuring students understanding about the Australian education and training system, and their knowledge of how students moved from one sector to another (advanced standing or credit-transfer). International fee-paying students do not encompass students on exchange programs or students studying courses of short durations.

BACKGROUND

The numbers of international students and the subsequent scale of this activity have grown quickly in the last two decades, as evidence shows in Table 1. A number of Australian institutions operate offshore either in their own right (eg Curtin University of Technology, Miri, Malaysia) or in twinning arrangements where offshore students gain advanced standing or recognition for their previous studies at Australian institutions.

Table 1
International Students Studying in Australia

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enrolments (2004)</td>
<td>322,776</td>
</tr>
<tr>
<td>International Students (2004)</td>
<td>269,205</td>
</tr>
<tr>
<td>Studying Science and Engineering (2004)</td>
<td>57,964</td>
</tr>
<tr>
<td>Gender profile of international students (2004)</td>
<td>52.81 %</td>
</tr>
<tr>
<td>Males</td>
<td></td>
</tr>
<tr>
<td>Institutions Registered on CRICOS</td>
<td>1256 (2003)</td>
</tr>
<tr>
<td>Employment</td>
<td>50,000</td>
</tr>
<tr>
<td>Value to the Australian Economy</td>
<td>$5.2 Billion</td>
</tr>
</tbody>
</table>


In 2003 there were 303,324 international enrolments. The majority of students studied in the higher education sector (Table 2). All sectors had international students. The ELICOS sector operates predominately for this clientele. There is a distinction between the term enrolment and students. Many students enrol in an initial course of English (ELICOS) and then continue onto another course in the same year (Table 1 gives the two figures for 2004 when 269,205 students were recognised as 322,774 enrolments).
Table 2

*International Students by Sector 2003*

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>26,799</td>
<td>9</td>
</tr>
<tr>
<td>Vocational Education &amp; Training (VET)</td>
<td>57,326</td>
<td>19</td>
</tr>
<tr>
<td>English Language Intensive Course for Overseas Students (ELICOS)</td>
<td>60,930</td>
<td>20</td>
</tr>
<tr>
<td>Higher Education</td>
<td>136,252</td>
<td>45</td>
</tr>
<tr>
<td>Other</td>
<td>22,017</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>303,324</strong></td>
<td></td>
</tr>
</tbody>
</table>


Table 3

*International Students - Science and Engineering Students Studying Selected Courses of Study in Higher Education and VET 2004*

<table>
<thead>
<tr>
<th>Field</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>14,927</td>
</tr>
<tr>
<td>Science</td>
<td>43,037</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>57,964</strong></td>
</tr>
</tbody>
</table>


The field of study of Science was defined by Australian Education International as Anatomy, Biochemistry, Biology, Botany, Chemistry, Computer Science, Geology, Home Economics, Human Movement, Information Systems, Mathematics, Microbiology, Nautical Science, Physics, Sports Science, Statistics, and Zoology. Some change of the Science field occurred during the study, especially in relation to Computer Science. Engineering encompassed Aeronautical, Chemical, Civil, Electrical, Electronics, Industrial, Marine and Mechanical Engineering, together with Cartography, Metallurgy and Surveying. The targeted fields of study comprised a student population of 31.4 percent of the total higher education and VET student enrolment (Table 3).

The most significant source of international students to Australia comes from Asian countries (occupying nine of the top ten source countries, Table 4). The People’s Republic of China (PRC) is a considerably bigger source than any other country (18%) and the Hong Kong Special Administrative Region (7%) making a total of a quarter of international students in Australia.

Table 4

*Source Countries for Top Ten International Fee-Paying Students to Australia – 2003*

<table>
<thead>
<tr>
<th>Rank</th>
<th>Country</th>
<th>Number</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PRC</td>
<td>57,579</td>
<td>18</td>
</tr>
<tr>
<td>2</td>
<td>Hong Kong SAR</td>
<td>23,803</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>South Korea</td>
<td>22,159</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>Indonesia</td>
<td>20,336</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>Malaysia</td>
<td>19,779</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Japan</td>
<td>18,987</td>
<td>6</td>
</tr>
<tr>
<td>7</td>
<td>Thailand</td>
<td>17,025</td>
<td>5</td>
</tr>
<tr>
<td>8</td>
<td>India</td>
<td>14,386</td>
<td>4</td>
</tr>
<tr>
<td>9</td>
<td>USA</td>
<td>12,189</td>
<td>4</td>
</tr>
<tr>
<td>10</td>
<td>Singapore</td>
<td>11,843</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Other</td>
<td>85,238</td>
<td>34</td>
</tr>
<tr>
<td><strong>Total All Countries</strong></td>
<td><strong>303,324</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: IDP Education Australia (2004)
INSTRUMENTATION

The development and implementation of the survey instrument were informed by the nature of the target audience. A ‘tick a box’ approach was adopted in order to improve clarity and to limit the number of additional responses that students needed to make. The instrument included 39 items but most students only needed to complete 30. The majority of items used a 5 point scale for responses (excellent, good, satisfactory, needs improving and unsatisfactory). There were six sections covering demographics, educational background, and the current course of study, future educational studies, career intentions, and contact details (this was optional).

Considerable time was spent on developing the survey instrument given that for the majority of the targeted sample their first language was not English. There was the need to trial the items and ensure that they were clear in their meaning and avoided any culturally specific terms. This allowed for consideration of what Lent & Worthington (2000) termed “cultural validity” (p. 382). Designing the instrument for a diverse range of cross-sectoral students added to the complexity of the task.

Drafts of the survey instrument were sent to a number of professional bodies for comment. The survey was trialled with small focus groups drawn from students in education sectors. This was particularly pertinent given the need to ensure an appropriate range of response options for each item. Some international student advisors were also asked to comment on the suitability of the language of the instrument items.

Some items dealt with the structural aspects of education and training (i.e. Question 7 Most recent course completed and Question 15 What course are you studying now?) while other items considered where the student had studied (Question 8), the nature of the qualification (Question 9 a, b, 13 a, and 17), mode of delivery (Question 9 d, e and 13c, d). Nearly 25 percent of Australian international students are studying offshore at Australian institutions or undertaking accredited programs in local institutions. Question 9a asked students to identify whether they fit into this category of having undertaken a ‘twinning’ program. Questions 11a and 11b (Table 5) asked students to comment on the transition process from studying in their offshore course to the course undertaken in Australia.

<table>
<thead>
<tr>
<th>Questions 11a and 11b Offshore to Onshore Transition</th>
</tr>
</thead>
<tbody>
<tr>
<td>11a. What has been your greatest concern in changing from your home country to study in Australia?</td>
</tr>
<tr>
<td>(Tick one box only)</td>
</tr>
<tr>
<td>English Language □</td>
</tr>
<tr>
<td>Study Methods □</td>
</tr>
<tr>
<td>Australia □</td>
</tr>
<tr>
<td>Teaching Style</td>
</tr>
<tr>
<td>Other adjustment to living in</td>
</tr>
<tr>
<td>Other (Describe)</td>
</tr>
<tr>
<td>11b. How have you found the course work in Australia?</td>
</tr>
<tr>
<td>Very difficult □</td>
</tr>
<tr>
<td>Difficult □</td>
</tr>
<tr>
<td>About the same □</td>
</tr>
<tr>
<td>Very easy □</td>
</tr>
</tbody>
</table>

A number of items explored the students’ career pathway. Question 19 asked Do you know what credit-transfer is? Yes /No. Question 27 was about recognition of the course by a professional body or society in the students’ home country and Question 28 asked how the student had found out the information in relation to Question 27. Question 33 asked the student whether they planned to add to their existing qualification with an additional Australian qualification.

A number of items asked about career advice. Questions 34 asked about career preparation in the students’ home country and Question 37 about career advice being accessed at the current educational institution. Questions 20 asked about the source of information about credit-transfer, Question 28 about the source of information about the recognition of courses. Question 35 asked for the students’ intended career and Question 36 asked about the relationship between intended career and current course (How well do you think your current course will prepare you for this career?). Question 38 asked about the effectiveness of current career advice (Table 6).
Table 6
Effectiveness of Career Advice Currently Accessed

38. If you answer YES in Question 37, how effective was this advice?

- Excellent
- Needs improving
- Good
- Unsatisfactory
- Satisfactory

PROCEDURE

The target population data was investigated in 2002 and 2003. Details on population sizes and proposed samples are discussed in more detail elsewhere (Calvert, 2003). Tables 2 and 3 indicate the scope of the potential target audience.

Fourteen institutions registered on the Commonwealth Register of Institutions and Courses for Overseas Students (CRICOS) were approached to participate in the study. Of these seven agreed but completed questionnaires were received from only six. The school approached was a state government education department. Questionnaires were distributed at five schools and completed questionnaires received from four of these. Whilst the number of institutions approached seems small these institutions had considerable numbers of students (see Table 9) and were distributed across the sectors reflective of the international student numbers in each sector (Table 8).

The questionnaires distributed to a contact at each institution for internal distribution according to a pre-arranged profile (for higher education institutions a 70:30 split between undergraduates and postgraduates was aimed for, to be reflective of the international student population in this sector). A batch number was printed on the questionnaire in order to be able to identify the originating institution. The questionnaires had a return envelope enclosed. The distribution occurred in September 2003. One institution (a university) distributed the questionnaire electronically. The support of the peak organisation representing international students studying in Australia (the National Liaison Council for Overseas Students or the NLC was also sought in order to increase awareness amongst students about the study.

It was planned to distribute 400 questionnaires but as a consequence of one institution sending the questionnaire out electronically, in excess of 2,250 questionnaires were disseminated. Given the size of this distribution the subsequent response rate was less than had been anticipated (Table 7).

The questionnaire sample size was 110. The sample represented students from 23 countries including PRC, Malaysia, Indonesia, Singapore and Hong Kong Special Administrative Region. Of this sample 57.2% were males. The majority of the sample was studying in higher education courses (Table 7).

Table 7
Sample Size by Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Questionnaire</th>
<th>Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schools</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>VET</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Higher Education</td>
<td>84</td>
<td>20</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110</strong></td>
<td><strong>22</strong></td>
</tr>
</tbody>
</table>

The number of completed questionnaires was less than had been planned for. Timing of the distribution of the questionnaires towards the end of the academic year may have contributed to the level of response. A lack of awareness of other questionnaires being sent to students at about the same time, including course completion questionnaires (for some students these were mandated as part of the course requirement) may also have impacted on the response rate. Awareness of the study through the NLC was limited.
It had been planned to follow up some of the questionnaire responses by conducting interviews. This became more significant as part of the methodological processes of the study because of the low response rate to the questionnaire. Focus questions were developed for the interviews. Interviews were conducted one-on-one either in person or by phone with twenty two students (14 males and 8 females) in 2004. The interviews were taped. The transcript of the interview was subsequently emailed to the student for verification and corrections made where necessary. This allowed for what Guba & Lincoln (1989) describe as “member checks” (p. 238). This sample represented students from eleven countries (especially Malaysia, Hong Kong SAR), 5 institutions and 4 sectors.

Responses from both the questionnaire and interviews were shared with the relevant institution for comment and to validate the data. Feedback from the institutions was incorporated into the study. Because responses were limited from some sectors analysis of data (especially VET) had to be aggregated. This occurred especially in entering the data into the Statistical Package for the Social Sciences (SPSS) statistical software package. The SPSS package was used to determine statistically significant associations.

Table 8
Institutions

<table>
<thead>
<tr>
<th>Sector</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Education</td>
<td>4</td>
</tr>
<tr>
<td>VET</td>
<td>2</td>
</tr>
<tr>
<td>School</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>

Table 9
Institutions Approached by Enrolment of International Students

<table>
<thead>
<tr>
<th>Sector</th>
<th>Institution</th>
<th>Engineer Rank</th>
<th>Computer Science Rank</th>
<th>Science Rank</th>
<th>International Students Enrolments 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Education</td>
<td>1</td>
<td>2257</td>
<td></td>
<td></td>
<td>2257</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>13624</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>15996</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>14</td>
<td></td>
<td></td>
<td>1899</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>3</td>
<td>6</td>
<td></td>
<td>33776 of 136,252</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>5</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>10</td>
<td>309</td>
<td>309 of 57,326</td>
<td></td>
<td>45</td>
</tr>
<tr>
<td>VET</td>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schools</td>
<td>13</td>
<td>561 of 26,799</td>
<td></td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>Total</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>303,324</td>
</tr>
</tbody>
</table>
DISCUSSION

There are a number of challenges to gathering meaningful data. Guba and Lincoln (1989) discuss what they describe as “fourth generation evaluation” and identify the need to address both the “trustworthiness criteria” and “the authenticity criteria” (p. 233). The sample sizes in this study required a modification of the methodology by increasing the interview sample size and sharing the feedback of both samples with key staff at the relevant institutions. In undertaking this Guba and Lincoln’s two conditions of “fourth generation evaluation”... “the claims, concerns, and issues of stakeholding audiences [in utilizing] the methodology of the constructivist paradigm” (p. 71) were met.

Consideration was given to back-translation of the questionnaire. This would have involved the translation of the English questionnaire into a variety of community languages. This may have improved the meaning of the questionnaire for the participants, however, given the method of dissemination it proved not to be practicable. The survey instrument proved to be a robust one given the variations in sectors, courses and the variety of the international student population. An additional item could have been included to gather data on the numbers and circumstances of students studying combined degrees.

The consideration of sample sizes was based on that outlined in Krejcie & Morgan (1970). Given the random and voluntary nature of the survey and the reliance on contacts at institutions it was difficult to identify individuals to send reminders to.

Interview participants were identified as a result of the questionnaire respondent volunteering their contact details. The interviews were arranged in the subsequent academic year to the questionnaire. It was subsequently found that a number of student’s email contacts were no longer in operation as either the student was no longer using this account or the institution had made the account inoperative. The interview sample represented twenty percent of the questionnaire sample.

The major issue with regard to the questionnaire sample was not so much the size or the numbers of institutions approached but rather the response rate of questionnaires returned. Here the dispersal of the enrolments across several institutions made sending information about this study to engender support for participating in the questionnaire sample difficult when compared to dealing with students at say one institution.

A great deal of planning for appropriate sample sizes can occur but ultimately with any data gathering from voluntary participants it depends on whether the individual wishes to participate. This makes for the need to reconsider quantitative and qualitative methods and in particular test the validity of the data that is collected. Here the use of “peer debriefing” (in this case the taking of the data back to the participating institutions), “member checks” (forwarding the transcriptions back to the students for checking) and being guided by the framework that Guba & Lincoln (1989) propose maintains “accountability” and recognises that “evaluators are subjective partners in the literal creation of data” (p. 45).

REFERENCES


75
DESIGNING LEARNING ACTIVITIES FOR A TECHNOLOGICALLY INTEGRATED CURRICULUM (TIC)

Vinesh Chandra
Queensland University of Technology
Australia

ABSTRACT

Information and Communication Technologies (ICT) now play a significant part in many classrooms. New and sophisticated technologies are introduced to the education market regularly. But no matter how good the tools, unless teachers are convinced and willing to design, develop, and implement appropriate pedagogies that use the new technologies; the new gizmos are unlikely to succeed in classrooms. In many schools across the globe, teachers have blended new technologies in an array of innovative ways. This paper describes such an initiative which is currently underway at a high school in Queensland, Australia. A group of year eight students (first year in high school) and their teachers in the Technologically Integrated Curriculum (TIC) Program use ICT and related technologies in all their subjects. Purpose-build rooms accommodate the students to do their work at school. They also use Blackboard to access learning materials after school hours. Qualitative data were gathered from teachers (N = 10) through structured and unstructured interviews to ascertain their perceptions of the new initiative. Teachers in this program had between 5-30 years of teaching experience. This investigation identified challenges faced by teachers and identifies the factors and the key questions associated with designing learning activities in a technology rich learning environment.

INTRODUCTION

Personal computers began appearing in schools more than 25 years ago. The Commodore 64 was one of the first computers which offered educational possibilities in terms of word processing and creating spreadsheets. More recently Information and Communication Technologies (ICT) have become more efficient and affordable with an array of possibilities for educational purposes. As a consequence they have become a tool which is becoming very common in classrooms.

There were at least three important questions – vocational, pedagogical and societal that have dominated the use of ICT in education (Wellington, 2005). One pedagogical question is the effect that ICT has on the role of the teacher. With new and smarter technologies, the role of the teacher is progressively changing as the “sage on stage” to the “guide on side”. As teachers turn more towards Information and Communication Technologies (ICT) for facilitating teaching and learning, their role as the “sage on stage” is quickly transformed to “a guide on the side”. McKenzie (1998) argued that a good teacher knew “when to act as sage on the stage and when to act as guide on the side” (para. 10). According to Papert (1999), digital technologies create new opportunities for students to explore the wider world. However, these tools are useless unless teachers can effectively blend these tools into learning activities.

There are a number of frameworks which propose how teachers embrace new technologies. Newhouse, Trinidad and Clarkson (2002) for instance proposed five stages which describes how teachers engage with technologies. The first three stages – “inaction”, “investigation” and “application” describe a progressive enhancement in teachers’ abilities to use the technologies in the classroom. The transition from “application” to “integration” is significant because teachers go past a threshold which Newhouse, Trinidad and Clarkson describe as the “critical use border”. By the time the teacher reaches the “transformation” stage, he or she can take leadership roles and demonstrate attributes of a leading teacher in ICT.

The ACOT (Apple Computers of Tomorrow) research project (1985 – 1995) mirrors some of the stages highlighted by Newhouse, Trinidad and Clarkson (2002). The ACOT project (ACOT, 1995) describes five iterative processes – “entry”, “adoption”, “adaptation”, “appropriation” and “invention”. Learning to use the new technologies is an iterative process and even those who have reached either the “invention” or “transformation” stages have to learn and unlearn about teaching with new technologies.

This paper presents some of the findings of a year long study where ICT was blended at a high school in two year eight classes across most of the subjects. Teachers in the Technologically Integrated Curriculum (TIC) Program volunteered to teach in their respective subject areas. All teachers in the study were at least in the “adaptation” stage
(ACOT, 1995) of ICT implementation. This qualitative study focuses specifically on the issues and challenges which teachers faced as they planned and prepared for the new program.

RESEARCH METHODOLOGY

Context

The TIC program was designed and implemented in year eight classes (first year of high school) at a state school in Queensland, Australia. Two out of eleven classes (55 students - 36 males and 19 females) were taught using computers. Lessons in English, Mathematics, Science, Studies of Society and the Environment (SOSE), Languages Other Than English (LOTE) and Health and Physical Education (HPE) were created using ICT. Two custom built rooms catered for the needs of the students. One of them was student focussed with a computer for each student while the other was teacher centred but also created numerous opportunities for collaborative tasks. Each room had a data projector and the computers were equipped with a wide range of up-to-date educational and industry standard software. Digital cameras were available for student use and the teacher centred room had an electronic whiteboard.

The TIC program was developed with the following objectives:

a) Actively engage students in learning
b) Improve literacy and numeracy through the use of technology
c) Enhance Information Technology skills
d) Increase students motivation to learn
e) Provide greater access to learning resources
f) Provide greater flexibility to address the needs on individual learners
g) Provide access to learning materials outside school hours and increase the involvement of parents

On average students participated in learning activities in the rooms for at least 75% of the day. They also had access to learning activities after school through Education Queensland’s Blackboard site. Students joined the program through an application process. However, the selections were not made on the basis of academic or ICT ability. These selections were based on the data provided by their primary schools on their abilities to work independently. Students also had to pay a relatively small fee to enrol in the program.

Planning and preparation for the course began almost a year before the program was implemented. This investigation focussed specifically on the design phase (prior to the implantation of the program) as teachers planned and prepared to implement the new program.

Participants

Twelve teachers were directly involved in this project. Of the twelve, ten agreed to participate in this investigation. The teachers taught English, Mathematics, Science Studies of Society and the Environment (SOSE), Languages Other Than English (LOTE) and Health and Physical Education (HPE).

Data collection and analysis

The major data collecting strategy employed in this part of the study was in-depth interviewing. Teachers were interviewed at pre-determined locations. Interviews and conversations were recorded and transcribed. They were asked to reflect on the design phase (before the program was implemented) as they answered the following questions:

1. How did you go about designing lessons for the TIC program?
2. What were some of the challenges and problems you faced? How did you address them?

RESULTS AND DISCUSSION

The implementation of each new program in a school environment brings on new challenges for teachers. Some of these challenges are anticipated and factored in the design process program while others emerge (sometimes unexpectedly) as implementation starts. For this reason understanding the issues and how they are addressed by
Teachers in the design phase is important. In this study teachers were asked to identify some of the issues which were most significant to them as they planned learning activities for the TIC program.

All teachers acknowledged that they had to rethink the teaching learning process. For some teachers the TIC program was viewed as an opportunity to initiate a curriculum renewal process. It gave them an incentive to revisit what they were teaching and how they were teaching it.

TIC gave us an opportunity to revalue courses. For instance, our program was revamped and the learning activities were centred on the new textbook because all students had to purchase one.

We had a new syllabus we had to make changes anyway and looking at how we could enhance what we were already doing in cyberspace and incorporating it into the existing work.

The school took a conservative approach to the implementation of the new program – only one variable of the teaching-learning cycle was predominantly changed to keep the new challenge manageable. As one of the teachers pointed out – the challenge was to have a course built from the old course. TIC and non-TIC classes were essentially addressing the same learning outcomes, covering the same content and finally doing either similar or the same assessment. However, one significant difference was in the pedagogies that teachers used to present their lessons – this was the only variable within the teaching-learning cycle which was changed significantly. Designing learning activities in a technology rich learning environment was a challenge especially in the absence any suitable models which paralleled this context.

It was also difficult because no other schools were trying this and there are no models to go by.

The teachers addressed the challenge in different ways. In one of the subjects the approach was to keep the new textbook as the focus for developing the learning activities and use some of the resources in the accompanying CD. In another subject, the approach was to audit what was there already and then decide what new initiatives could be undertaken.

The course design and the content was kept the same for all students but varied the assessment tasks to suit TIC and non-TIC students. The CD accompanying the textbook had internet sites to support the lessons together with some good little quizzes and flashcards for definitions.

We did a review of what was available...we looked at the program as it was and explored ways to keep the program similar and areas where we could slot the [technology based] exercises in...

In Mathematics, the school had already decided to purchase a software package that would be used by TIC classes. However, teachers did not have access to the program at the time learning activities for the TIC program were designed and as a consequence spent their time on semester planning.

The Mathematics Department had already decided to use this new software and as a consequence the teachers did not have to think too much in terms what the relevant software they have to use. The software was also packaged with other applications e.g. drawing graphs. In terms of planning ...we didn’t have the program so most of the time was spent selecting what topics we wanted to do...and work on semester plan

While in Mathematics, software was not an issue, in other subjects not knowing enough about which packages were available was problematic. Teachers knew of some resources that could be used for parts of the course, but not knowing enough about what ICT based resources were available on specific topics was an issue.

One of the greatest challenges was designing appropriate assessment...the hardest part was coming up with the assessment items using a range of technologies, because we didn’t know what most of it was...We knew there was PowerPoint...we couldn’t have every assessment piece based on PowerPoint.

Yeah not knowing ...for the first term... I have been able to use what is already out there... but next term there are more specific topics and there isn’t a lot out there in terms of online resources.
Given that this program was new, teachers understandably had other issues in terms of what was expected of them and more importantly predicting how successful some of their lessons would be when these resources were used in TIC classrooms. There was a certain degree of uncertainty in terms of how it would pan out. Limited access to computer rooms also prevented teachers from trialling certain ideas before they were implemented in the TIC classes.

It wasn’t easy. I didn’t know what was available or what was expected of me... and coming up with ideas. I really wanted the first year to be just manageable. To get it done so it wasn’t a big flop. I have been looking at technology and games for my classes but because of limited access to computers I haven’t be able to use it. I have looked at a lot of packages and websites that were already out there; but the planning was still very hard...

Whether we had the technology here to do the work and locating the work you wanted to do and then looking to see if we had the ability to achieve this goal....

I felt really anxious about what was expected of me.

The school had a number of highly skilled technology staff; however there were no local experts (eg. e-learning specialist) who could specifically support and advice teachers in terms of how to blend the technologies in their respective subject areas. The program had a TIC coordinator who had other teaching responsibilities and supported the teachers in the best ways possible. Teachers were highly appreciative of the support they were getting from the coordinator and other technology staff.

Time allocated for designing and planning activities was also an issue. Some teachers felt that more time should have been allocated to enable them to plan and search for appropriate software packages and resources that were available online. There are some good links to websites – but they needed time to structure their search, explore the content, and establish its credibility and suitability for developing learning activities. Teachers also needed time to discuss with other TIC teachers to establish what they were doing. They did not want to unknowingly step on other teachers toes by using their ideas.

With regards to hardware and software issues... the time needed to review the program not in an ad hoc way but sit down and look at it. Talking with other teachers in other subject areas helps and you get ideas...

Most of the teachers engaged in this program would either be in the “application” or “integration” stages of technology users in their classrooms (Newhouse, Trinidad & Clarkson, 2002). However, some were at the “transformation” stage where they knew exactly how to design lessons and had their own innovative ideas.

We have a booklet which is like a textbook. I did PowerPoint presentations and have a subscription to a website now. I can get language games...I provide the raw data and the site converts it into a java game and the kids have access to it with a password. It’s an American site and it cost us about 50 USD.

Implications for teachers

While teachers entered this program with varying abilities and beliefs about a technologically integrated curriculum, they all seemed to appreciate the experience. There was an overwhelming belief amongst the teachers that despite some of the challenges and issues highlighted here they all believed that it was a worthwhile experience. They all understood what they were trying to achieve.

...we wanted to use technology to enhance learning and not learn technology...Make it [Lessons] interesting and engage students but keep the academic rigour

This investigation focussed on the challenges faced by teachers when they design learning activities in a technology rich learning environment. It identified some of the issues in the initial stages - prior to the implementation of the program (Table 1).
Table 1

Factors and Key Questions Associated with Designing Learning Activities in a Technology-rich Learning Environment

<table>
<thead>
<tr>
<th>Factors</th>
<th>Key questions for teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curriculum renewal</td>
<td>How can we do the learning activities differently?</td>
</tr>
<tr>
<td>Textbook</td>
<td>How can we blend this resource in the new environment?</td>
</tr>
<tr>
<td>Course audit</td>
<td>What resources do we have already?</td>
</tr>
<tr>
<td>Resources</td>
<td>How and where do we find new resources?</td>
</tr>
<tr>
<td>Models</td>
<td>Has a similar approach been trialled elsewhere?</td>
</tr>
<tr>
<td>Time</td>
<td>How do we plan as a team and find resources?</td>
</tr>
<tr>
<td>Trailing ideas</td>
<td>Can we trial ideas before we implement them?</td>
</tr>
<tr>
<td>Teacher support</td>
<td>Who do we ask when we have a problem?</td>
</tr>
</tbody>
</table>

Table 1 highlights the key factors and the key questions that are relevant when learning activities using technologies are designed. Teachers have different levels of expertise in the use of technologies and as a consequence the extent to which the factors impact on them could vary. The TIC program can serve as an effective model for teachers as they design learning activities for a technology rich learning environment. Further research on this project is underway.

REFERENCES

ABSTRACT

In many education systems in the western world, Design and Technology is now an important part of the school curriculum. In Queensland, Australia, Technology is one of the Key Learning Areas (KLA’s) for students in compulsory years of schooling. The Technology Syllabus was completed and trialled in Queensland primary schools in 2003. The syllabus encourages students to think creatively and work technologically. This paper describes how design and technology was taught to pre-service primary teachers at an Australian University. The pre-service teachers were involved in a range of activities which promoted creative thinking, active learner involvement, team work, problem solving, working technologically, and engagement in authentic tasks. The tasks included designing and making products such as kites, land yachts, towers, bridges, and LEGO robots. Activity sequences, based on the products made, are planned by the pre-service teachers and involve the phases of the Technology Practice Cycle identified in the Technology Syllabus. Teams of pre-service teachers also used the cycle of Investigate, Ideate, Produce, and Evaluate, to create their own technology products. The use of Wikis, Blogs, and digital videos are integral to sharing ideas within the teams of pre-service teachers and across the unit cohort. The paper also provides examples of pre-service teacher feedback on various aspects of the Design and Technology unit.

INTRODUCTION

Design and technology have played a significant part in the “evolution” of the human race. The ability of humans to conceive ideas and transform them into reality has been an important part of the evolution process. The economic prosperity of many nations depends upon its citizens to innovate and deliver products to fulfill human needs and wants. Yet within the schooling system in Australia, design and technology has not been a priority area until recently. In primary schools, technology was embedded in the science course while in high schools it was taught as an optional specialist subject; such as woodwork, metalwork and home economics. It appears that technology education has “struggled to establish itself as an equal partner in general education and often struggled to gain recognition for the value of its instruction” (De Miranda, 2004, p. 61).

In countries such as the USA and England, Design and Technology has been a part of the school curriculum for sometime. However, it is believed that the content covered by K-12 technology, innovation, design, and engineering (TIDE) educators in the U.S. was not sufficient to advance the innovation agenda (Starkweather, 2005). According to Starkweather “the mentality of educational systems in the majority of countries overlooks the attributes of a TIDE education, does not include the big picture of innovation, is shortsighted, or does not exist at all”(p. 29). Starkweather also believed that the importance of TIDE subjects to demonstrate innovation and invention outcomes had diminished because teachers have not “always been taught to explore the virtues of innovation as part of the curriculum” (p. 29).

In England on the other hand, it was reported that there were fewer examples of good teaching in design and technology than in other subjects (HMI, 2004). A beginning teacher’s experience in a design and technology classroom in a Queensland (Australia) school revealed that her limited knowledge of the topic and the syllabus impacted on her ability to conceptualise and implement appropriate learning experiences (Stein, Ginns & McRobbie, 2003). Findings such as these suggest that pre-service teaching courses should enable students to embrace innovation and inventions ideas in order to enable them to create productive learning environments in their classrooms. They should also have an understanding of the concepts and confidence to implement learning activities once they qualify as teachers.

DESIGN AND TECHNOLOGY IN QUEENSLAND

In Queensland (one of the six states in Australia), the curriculum in the first ten years of schooling is divided into eight Key Learning Areas (KLA’s). Technology is one of the KLA’s. This syllabus was
first introduced in 2003 and it became compulsory in all schools in 2007. The syllabus describes technology as follows:

*Technology involves envisioning and developing products to meet human needs and wants, capitalise on opportunities and extend human capabilities. Products of technology include artefacts, processes, systems, services and environments. These products make up the designed world. Products of technology have impacts and consequences on individuals, local and global communities, and environments.*

(Queensland Studies Authority, 2003, p. 1)

The syllabus emphasises the idea of working technologically which is achieved by applying the four learning outcomes embedded across four strands – Technology Practice, Materials, Information, and Systems. The Technology Practice Cycle forms an important part of the Technology Practice Strand. When creating a product, it emphasises the importance of the four critical inter-related phases - Investigation, Ideation, Production and Evaluation. The syllabus also highlights the importance of appropriateness, context, and management in relation to product development (Figure 1).

![Layout of the Queensland Technology Syllabus](image)

*Figure 1. Layout of the Queensland Technology Syllabus.*

**Design and Technology for pre-service teachers**

The unit in this investigation gave the pre-service teachers an opportunity to examine teaching and learning issues inherent in the four strands of the Technology KLA. This included content and pedagogical issues associated with design and technology education. Assessment and workshop tasks were aimed at promoting teamwork and in the process developing a thorough understanding of the Technology Practice Cycle and how it fitted in with the rest of the syllabus. Collectively these approaches promoted attributes of life long learning such as: developing a deep understanding of the concepts, actively investigating, effectively reflectively and communicating their results (Queensland Studies Authority, 2003, p. 1).

Project-based learning was a significant part of student assessment within the unit. Such an approach enables students to engage students in a sustained and cooperative investigation (Bransford & Stein, 1993). This approach “takes the focus off the teacher imparting knowledge to the students and places it onto students working together to actively construct meaning.” (Cole, 2003, p. 16) It is well aligned with a constructivist approach where students are “active agents in a learning process characterised by recurrent cycles of analysis and synthesis, action and reflection” (Mioduser & Betzer, 2007, p. 61). Significantly, students engage in real life “hands-on” activities, solve realistic problems, and understand limitations of what is doable before the final product is produced.
The Project-based learning approach adopted in this instance enabled students to engage in a recursive cycle of Investigation, Ideation, Production and Evaluation – all of which are essential phases of the Technology Practice Cycle. In doing so they engaged in the strands of the Technology syllabus – Information, Materials, and Systems. One significant aspect of this task was that the project involved teams of students creating a product of their own choice. Tutors helped students to refine their product choices if there was a need.

**METHOD**

The Queensland Technology Syllabus was an important part of the teacher training unit. Lectures, workshops, and assessment tasks were geared towards giving the students an understanding of design and technology concepts and the skills needed to unpack and implement the syllabus document in their future classrooms.

The first assessment was based entirely on the workshop activities. Kites, containers, marble machines, bridges, towers, Lego robots, and land yachts were some of the products created in the workshops. Images of products created by students in these workshops were used to produce a multimedia presentation (using *Microsoft Photostory 3 for Windows*) each week. These multimedia slideshows were shown at the beginning of the tutorials and were made available on the unit’s Blackboard site.

These workshop activities highlighted the significance of a learner-centred approach which is considered to be an important element of the Technology syllabus (Queensland Studies Authority, 2003, p. 1). As part of the assessment, students used these activities to develop a design and technology portfolio which consisted of a number of technology lessons. Each lesson had to clearly state the learning outcomes, design challenge, materials list, and activity sequence.

The second assessment took a project-based learning approach and was an extension of the first assignment (Figure 2). They had to work in groups and construct a product using their own designs. More importantly this product was something that they would expect their students to produce in the future. Consequently they also had to backwards plan a curriculum proposal associated with their task. The choice of appropriate learning outcomes and an analysis of their learning were integral parts of this activity.

![Figure 2. Project-based learning model.](image-url)
The pre-service teachers formed groups with three to four members to complete their own technology products which were presented in class during the last week of the teaching semester. The groups had four weeks to decide on an idea and then design and construct their product. During their product construction the groups were engaged in the Technology Practice Cycle and other strands of the syllabus. An iterative cycle formed the basis of product construction where interactions occurred in a non-linear manner. Students would for instance, engage in the ideation phase of the development by taking into consideration aspects of the Materials strand of the syllabus. They would then investigate and evaluate the materials before moving to the production phase of the Technology Practice Cycle.

As part of this assessment the pre-service teachers were required to submit a classroom activity based on their product. They also had to complete a WIKI in which they reflected on their engagement with the Technology Practice cycle and other strands of the syllabus. They also had to reflect on six critical stages of product development in their WIKIS. An online group space with a range of tools such as email was provided for the groups as a collaboration tool for their assessment. The use of the group space was not compulsory. The group space included a blog, a chat room, and a file exchange system. Digital videos were taken of each group’s final product presentation and added to the Blackboard site so all the pre-service teachers enrolled in the unit could access ideas of other groups in the cohort. Students used the digital videos and the WIKIS to comment on another group’s presentation through a Blog which was specifically setup for this purpose.

Participants

The participants in this course consisted of two hundred and fifty third year pre-service primary teachers. This Design and Technology unit ran for ten weeks. The pre-service teachers complete the compulsory unit as part of their four year Bachelor of Education (primary) degree program.

Data collection

A descriptive case study was used for data collection and incorporated a questionnaire and a survey. A case study method was used in order to ascertain the viewpoint of the pre-service teachers enrolled in the unit.

A qualitative method was also used for data analysis, mainly because the focus of the study was concerned with the pre-service teachers’ perceptions of the learning activities and resources used in the unit. Data was collected in week four and week eight of the semester.

Week 4 Data

The data from week four consisted of answers to a questionnaire based on questions used in the Queensland Technology Syllabus Initial In-service Materials booklet (2003). Thirty one pre-service teachers from two tutorial groups where asked to individually complete the questionnaire.

After completing the Bridge and Tower activity in week 4 the pre-service teachers were asked to individually answer a series of questions. These questions were administered to establish students understanding of this task. Students answered the following questions:

- What was the first thing that members of your group did after reading the activity?
- Do you consider this to be a closed or open task?
- What did you notice about participation as the activity progressed?
- During the activity, did the group backtrack, start again, stop and review how the task was progressing?
- Did some testing take place when options were being considered?
- In considering ways in which the activity was undertaken, is it possible to specify occasions when investigation, ideation, production, and evaluation were taking place and whether these occurred in iterative, cyclic, or recursive ways.
- What strands with Technology Practice were you considering? (Materials, Information, Systems).
- What else could you consider? (Context, management, appropriateness).

Week 8 Data

Data from week eight consisted of responses to a survey which contained a Likert scale ranging from strongly disagree to strongly agree. The survey asked the pre-service teachers to give feedback on the Photo Story presentations, online group spaces, Wikis, and digital videos that were a part of the unit.
One hundred and seventeen pre-service teachers from six tutorial groups completed the questionnaire on the resources. The pre-service teachers were asked to rate each resource using the following criteria:

- The resources are easy to use.
- The resources are useful for the assignment or for future reference.

The pre-service teachers were also asked to comment on the most useful aspects of the resources and how they could be improved.

**Data analysis**

Data consisted of answers to a questionnaire and a survey. The survey was analysed by comparing the percentage of answers that fell into the different categories stated on the survey regarding how easy the resources were to use. The resources included the weekly slideshow, group space, and WIKI. The questionnaire was used to assess the perceptions of the pre-service teachers regarding one of the learning activities engaged in during the Design and Technology unit.

**RESULTS**

The data gave insights on the pre-service teachers’ perceptions of the learning activities and resources used in the unit.

**Week 4 feedback**

The results from the questionnaire completed in week four showed that the pre-service teachers were engaging with the Technology Practice Cycle during the Bridge and Tower structure activity. Responses included the following comments:

*Investigation was mostly done in the beginning where triangle was seen to be strongest shape. Ideation was in form of discussion and drawing. Production was iterative. Evaluation was done during the testing with weights*

*We investigated & designed a tower giving ideas of what would work & what wouldn't. The production was all hands on with evaluation occurring continuously throughout.*

Most of the pre-service teachers (88%) identified the task as an open task and stated that they drew or sketched their ideas on paper before their group constructed their structure. This finding relates to the design aspect of the Technology Syllabus (2003) where the sketching of designs prior to production is an important process.

Evaluation is also an important process in the Technology Practice Cycle and can occur at different stages of the cycle (Queensland Studies Authority, 2003, p. 1). Most pre-service teachers indicated that they either backtracked or reviewed the task as they completed the activity. The majority of the pre-service teachers (77%) also indicated that they tested their construction at different stages of the production. The pre-service teachers stated that they had used their hands to place pressure on the structure or used weight as they were building. Students explained their approaches as follows:

*Yes -we tested quite a bit which then led to other ideas if they didn't work*

*At some stages we added some weight to see if what we had decided to do would work*

*We kept on putting our hand on the tower's platform to test its stability*

However, about one fifth of the sample (19%) indicated that testing only occurred at the end of the activity. The final evaluation involved the pre-service teachers testing their structure by placing 1kg weights on the top. One pre-service teacher commented:

*All testing was done at the conclusion of the activity.*
The Materials strand of the Technology Syllabus was considered by the pre-service teachers as well as the Technology Practice strand. The pre-service teachers indicated that they also considered aspects of Context, Management, and Appropriateness as they completed the activity. One pre-service teacher listed all three aspects and described how they could be considered when using the activity in a classroom.

**Appropriateness** - of environment, functions & economic - what community? How big?
**Context** - where is the bridge for? A walking or transport
**Management** - timelines, managing of materials health & safety

**Week 8 feedback**

The results from the survey (see Table 1) completed in week eight were positive and showed that the majority of pre-service teachers found the resources used in the unit were easy to use.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Number of valid responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photostory slideshow</td>
<td>0</td>
<td>2</td>
<td>7</td>
<td>34</td>
<td>57</td>
<td>99</td>
</tr>
<tr>
<td>Group space</td>
<td>1.8</td>
<td>3.5</td>
<td>35.1</td>
<td>39.5</td>
<td>20.2</td>
<td>114</td>
</tr>
<tr>
<td>Wiki</td>
<td>0.9</td>
<td>10.8</td>
<td>20.7</td>
<td>42.3</td>
<td>25.2</td>
<td>111</td>
</tr>
</tbody>
</table>

The Photostory slideshows were created each week and students could view it as a media file through Blackboard. Students accessed the Wiki resource to reflect on their experiences of product development. The majority of the students believed that the Photostory slideshow and the Wiki were easy to use. Comparatively a smaller percentage (59.7%) either agreed or strongly agreed with the statement that the group space was easy to use. This response is acceptable given that the group space was not compulsory for students to access.

The qualitative data also showed that many believed that some of the resources which they accessed in the course were either useful for the assignment or for future reference (Table 2).

<table>
<thead>
<tr>
<th>Resource</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
<th>Number of valid responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photostory slideshow</td>
<td>0</td>
<td>1.7</td>
<td>12.8</td>
<td>56.4</td>
<td>29.1</td>
<td>117</td>
</tr>
<tr>
<td>Group space</td>
<td>3.5</td>
<td>4.4</td>
<td>36.0</td>
<td>43.0</td>
<td>13.2</td>
<td>114</td>
</tr>
<tr>
<td>Wiki</td>
<td>0</td>
<td>7.7</td>
<td>15.4</td>
<td>46.2</td>
<td>30.8</td>
<td>117</td>
</tr>
<tr>
<td>Digital video of products</td>
<td>0</td>
<td>0</td>
<td>14.2</td>
<td>46.9</td>
<td>38.9</td>
<td>100</td>
</tr>
</tbody>
</table>

In excess of 85% of the sample either agreed or strongly agreed that the weekly Photostory slideshows and the digital videos of the products were useful for the assignment or for future reference. The majority of the students either agreed or strongly agreed (76.2%) that the Wiki tool was useful either for the assignment or for future reference. The group space was seen as the least useful in terms of its usefulness for the assignment or for future reference. Only 56% of the sample either agreed or strongly agreed with its usefulness. As explained earlier, the use of this tool was not a compulsory part of the course – the optional nature of the activity probably did not motivate students to explore the usefulness of the tool.

Qualitative data gathered from the students provides further evidence on what the students thought about these resources. Students believed that the Photostory slideshows gave them an overview of how students built their products in other groups. They appreciated the time that was put into making these resources.
Weekly slideshow was awesome. I know it’s a lot of work but we appreciated it.

Loved the slideshow. It gave a great overview of what was achieved the week before. This is an idea I am using on my next practicum.

It appeared that students who used the group space found it useful. According to one pre-service teacher:

I loved the way that the group space and Wiki were used. It made doing group assignments loads easier.

While most students found the Wiki tool to be useful, about 11% of the sample (see Table 1) indicated that the Wikis were not easy to use. In the qualitative responses, four pre-service teachers commented that the Wiki would be more useful if it was included as part of the final team presentation. One of the pre-service teachers expressed her thoughts on the Wiki as follows:

Unfortunately the WIKI is a bit of a pain - I do see the point in it now, but I feel like it was a bit of a cut and paste project. It would have been good if it was a part of the actual presentation - used as a tool for explanation. Otherwise I loved this subject; it’s really engaging and making a product each week is quite rewarding.

The digital video of the groups’ presentations of their final products was seen as useful by the pre-service teachers. These videos were created to give students an idea of what others groups had achieved. It was a resource which added value to the content of the Wikis. Using these resources students commented on another group’s product – this was done online through a blog. Students’ responses to the digital video were expressed as follows:

Videos fun and helpful to see other ideas.

The video of products will be a great resource for us as future teachers

Videoing the products will be great too because some of these ideas are great and I would love to use them

DISCUSSION

This study focussed on aspects of students learning experiences and the effectiveness of some of the resources they had access to as they unpackaged the technology syllabus. Research has shown that in design and technology subjects there was lack of good examples which demonstrated good teaching practices (HMI, 2004). Preservice teachers also had difficulties implementing appropriate learning because of their limited knowledge of the topic and the syllabus (Stein, Ginns & McRobbie, 2003).

In this course, the workshop activities which students completed appear to have facilitated preservice teachers understanding of the syllabus. The survey administered at the end of week 4, gave an insight into students understanding of the bridge and towers activity. The majority of the students demonstrated an understanding of the nature of the task and how they engaged in the all phases of the Technology Practice cycle. It was interesting to note that students engaged in these phases differently. They were not following the four phases – Investigation, Ideation, Production and Evaluation sequentially but were engaging in these phases is a non-linear manner – as intended in the syllabus document. As they built their products, students were also incorporating aspects of the Materials strand and thinking about other aspects of the syllabus (i.e. context, appropriateness and management). The Bridge and Tower activity showed that the workshop challenges were increasing students awareness of the syllabus.

The Photostory slideshows were also giving students an opportunity to see how other students were addressing their design challenges. It gave them ideas on how a design challenge can be addressed in different ways, thus emphasising the point that a design challenge can be addressed differently. In one of the activities students were given the following challenge – “Design and make a package that will promote a new healthy snack product and will appeal to children”. The packages created varied and images of some of the packages used in the Photostory presentation are shown in
Figure 3. Such an approach gave students ideas as was evident in their qualitative responses. *(This is an idea I am using on my next practicum).*

The Wiki and the digital videos produced were also perceived by students as effective tools. The Wikis gave students an opportunity to reflect on their experiences. For instance one group which created a rubber-band propelled boat outlined their reasons for incorporating such an activity in a classroom as follows:

*This design challenge would be suitable for use in a classroom because it a simple yet effective learning activity which uses easily accessible materials and fosters student creativity and ownership of learning. The product being designed is easily relatable to the real world for any students who are familiar with water-based transport and the need for finding alternative means of powering this transport. As such, it would fit well within a larger, integrated unit on sustainable transport and would simultaneously address aspects of the futures perspective cross-curricular priority.*

The group was also able to identify specific requirements in order to ensure the success of the project. They noted the following:

*The tools and equipment ideally suited to this activity would require additional adult support and supervision (eg. hot glue gun; bowsaw, sidecutters).*

*An appropriate testing facility would be needed (eg. school pool, water trough, PVC piping cut in half, etc)*

**CONCLUSIONS/IMPLICATIONS FOR TEACHERS**

Design and Technology has not been a priority within the schooling system in Australia until recently. Technology is now one of the *Key Learning Areas* (KLA’s) for students in compulsory years of schooling. This article has presented some of the ways in which a Design and Technology unit was presented to a cohort of pre-service primary school teachers.

The pre-service teachers were involved in designing and making a variety of technology products. The pre-service teachers were also involved in designing and creating their own products incorporating the phases of the Technology Practice Cycle identified in the Technology syllabus (Queensland Studies Authority, 2003).

Two particular features of the study can be seen as important in developing the understanding of the Technology KLA. These are the Technology Practice Cycle of Investigate, Ideate, Produce, and Evaluate and the use of resources such as Wikis, Blogs, and digital videos for sharing ideas.

Encouraging pre-service teachers to engage in the same processes that are expected of their future students enables them to create productive innovative learning experiences. It also gives them the opportunity to gain an understanding of the concepts involved in the Technology Syllabus (Queensland Studies Authority, 2003). The team based activities promoted in this article highlight that pre-service Technology units should involve meaningful activities that encourage the students to incorporate the Technology Practice Cycle of Investigate, Ideate, Produce, and Evaluate. The findings also highlight that the use of resources such as Wikis, Blogs and digital videos are integral to sharing ideas within the teams of pre-service teachers and across the unit cohort.
REFERENCES


A LEARNING ENVIRONMENT STUDY OF TERTIARY CLASSROOMS AND STUDENTS’ ATTITUDES TO CHEMISTRY IN RAJABHAT INSTITUTES IN THAILAND

Chanes Kongkarnka and Darrell L. Fisher
Curtin University of Technology
Australia

ABSTRACT
The paper reports on the investigation of students’ perception of their chemistry learning environment in Rajabhat University in Thailand. A new instrument, the Tertiary Chemistry Learning Environment Questionnaire (TCLEQ) contained 49 items in seven scales; Student Cohesiveness, Cooperation, Equity, Integration, Investigation, Teacher Support and Material Environment and the Test of Chemistry-Related Attitudes (TOCRA) contained two scales; Adoption of Scientific Attitudes and Enj oyment of Science Lessons, were selected to investigate students’ perception and attitudes toward chemistry learning. A combination of quantitative and qualitative methods was used in this study. The qualitative methods involved classroom observation, student interviews, and teacher interviews. The study revealed that students showed a preference more favourable than what they perceived. Both male and female students perceived and preferred their learning environment similarly and student equity was found. Female students preferred a slightly more positive learning environment than did male students. Students’ attitudes to learning chemistry as indicated by the for Adoption of Scientific attitude scale were that students have an open-minde dness and willingness to revise opinions in their study. Also, they agree that they enjoyed their chemistry learning experiences. The findings indicated that there were positive associations between the learning environment dimensions and attitudes to chemistry.

Keywords: learning environment, perception, attitudes, quantitative and qualitative methods

BACKGROUND
Throughout the Rajabhat Universities of Thailand, there is a belief that our students encounter difficulties in both learning and achievement in chemistry. There are many factors that may contribute to students' lack of success and learning difficulties, such as students' preconceived attitudes to science, an overload of information in text books, non-scientific approaches by the instructor, students' misunderstanding and alternative conceptions, teacher-centred approaches, and the passive learning of students. Such factors indicate that instructors need to be facilitators with a new sense of teaching and learning.

The learning environment has long been perceived as an important factor influencing student behaviour and educational development. Also the class can be regarded as a social system in which group behaviour can be predicted from the interaction of personality needs, expectations and the classroom environment (Getzels & Thelen, 1960; Lewin, 1936; Murray, 1938). Fisher, Rickards, and Fraser (1996, p. 29) stated that: ‘Most science teachers believe that good relationships with their students are important, and students have encountered many different learning environments and have enough time in a class to discriminate between various classroom environments (Fraser, 1998a), and it is the teachers' responsibility to be forward-looking and to determine what trends are developing in the classroom.

Research objectives
- to modify and validate the What is Happening in this Class? (WIHIC) questionnaire for assessing students' perceptions of chemistry classroom environments in tertiary institutes in Thailand;
- to modify and validate the Science Learning Environment Inventory (SLEI) questionnaire for assessing students' perceptions of chemistry classroom environment in tertiary institutes in Thailand; and
- to investigate associations between students' perceptions of their learning environments and attitudes to learning in chemistry.

Research design
Instruments

Two instruments were employed in the present study. The first instrument, the Tertiary Chemistry Learning Environment Questionnaire (TCLEQ) was based on two instruments, the WIHIC and the SLEI. The TCLEQ was constructed originally in English language and subsequently translated into Thai for use in the present study. The TCLEQ contains both Actual and Preferred Forms. The second instrument, the Test of Chemistry-Related Attitudes (TOCRA) was modified from a ten-item Attitude Scale based on the TOSRA (Fraser, 1981). These
Instruments were translated from English into Thai, a rigorous procedure of back-translation (Brislin, 1970) was used to ensure accuracy.

The TCLEQ contains 49 items in seven scales, namely, Student Cohesiveness, Cooperation, Equity, Integration, Investigation, Teacher Support and Material Environment. Also, in the present study is aimed to investigate student's perceptions of their actual and preferred learning environment, the Actual and Preferred version of the TCLEQ were used, both of which were administered at the same time in the instrument. The instrument employs a five-point Likert scale with the alternative response format of Almost Never, Seldom, Sometimes, Often and Almost Always.

Table 1: Scale Description and Example of Items for each Scale in the TCLEQ

<table>
<thead>
<tr>
<th>Scale name</th>
<th>Moos' Scheme</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>R</td>
<td>Extent to which students know, help and are friendly towards each other.</td>
<td>I do favours for members of this class. (+)</td>
</tr>
<tr>
<td>Cooperation</td>
<td>P</td>
<td>Extent to which students cooperate with other students, working together and sharing of resources.</td>
<td>I cooperate with other students when doing assignment work. (+)</td>
</tr>
<tr>
<td>Equity</td>
<td>S</td>
<td>Extent to which all students are treated equally in their work in class.</td>
<td>I cooperate well with other class members. (+)</td>
</tr>
<tr>
<td>Integration</td>
<td>P</td>
<td>Extent to which the laboratory activities are integrated with non-laboratory and theory classes.</td>
<td>What I do in our regular chemistry class is unrelated to my laboratory work. (-)</td>
</tr>
<tr>
<td>Investigation</td>
<td>P</td>
<td>Extent to which the skill and processes of inquiry and their use in problem-solving and investigation</td>
<td>I carry out investigations to test my ideas. (+)</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>R</td>
<td>Extent to which teacher helps, befriends, trusts and is interested in students.</td>
<td>The teacher takes a personal interest in me. (+)</td>
</tr>
<tr>
<td>Material Environment</td>
<td>S</td>
<td>Extent to which the laboratory equipment and material are adequate.</td>
<td>I find that the laboratory is crowded when I am doing experiments. (-)</td>
</tr>
</tbody>
</table>

Adapted from: Aldridge and Fraser (1997) and Fraser, McRobbie and Fisher (1996). Items designed (+) are scored 1, 2, 3, 4 and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often, and Very Often. Items designed (-) are reverse scored.

Table 2: Descriptions and sample items of Scales of the Test of Chemistry-Related Attitudes (TOCRA)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>Measures attitude towards open-mindedness, willingness to revise opinions, etc.</td>
<td>Finding out about new things is unimportant. (-)</td>
</tr>
<tr>
<td>Enjoyment of Chemistry Lesson</td>
<td>Measures attitude to the enjoyment of science learning experiences.</td>
<td>Chemistry lessons are fun (+)</td>
</tr>
</tbody>
</table>

Adapted from Fraser (1981) Items designated (-) scored in the reverse manner.

Reliability and validity of the TCLEQ

Factor Analysis

Table 3 shows the factor loadings obtained when the individual was used as the unit of analysis for both actual and preferred versions of the TCLEQ that were given to each student. A principal components factor analysis followed by a varimax rotation showed that the factor structure obtained strongly confirmed a priori factor structure of the TCLEQ.
<table>
<thead>
<tr>
<th>Scale</th>
<th>Item No.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>P</td>
<td>A</td>
<td>P</td>
</tr>
<tr>
<td>Student</td>
<td>1</td>
<td>0.62</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>2</td>
<td>0.55</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>0.66</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0.58</td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>0.55</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>0.45</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>0.52</td>
<td>0.87</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>8</td>
<td>0.63</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>0.48</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>0.68</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>11</td>
<td>0.62</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0.62</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>0.66</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>0.66</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>15</td>
<td>0.68</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>0.73</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>0.72</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>0.77</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td>0.72</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.75</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td>0.75</td>
<td>0.76</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>22</td>
<td>0.42</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>0.62</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>0.58</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>0.70</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>0.66</td>
<td>0.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>0.74</td>
<td>0.61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>28</td>
<td>0.66</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>29</td>
<td>0.43</td>
<td>0.81</td>
<td>0.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.83</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>31</td>
<td>0.76</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>0.77</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>0.69</td>
<td>0.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>35</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher Support</td>
<td>36</td>
<td>0.71</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37</td>
<td>0.72</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>38</td>
<td>0.77</td>
<td>0.78</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>0.66</td>
<td>0.64</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>0.68</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>0.67</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>42</td>
<td>0.48</td>
<td>0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>43</td>
<td>0.63</td>
<td>0.91</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment</td>
<td>44</td>
<td>0.83</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>0.67</td>
<td>0.89</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>46</td>
<td>0.70</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47</td>
<td>0.83</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>48</td>
<td>0.78</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>49</td>
<td>0.67</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>% Variance</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actual</td>
<td>10.79</td>
</tr>
<tr>
<td>Preferred</td>
<td>12.34</td>
</tr>
</tbody>
</table>

Factor loadings less than 0.40 not shown, n = 721
Internal consistency reliability and discriminant validity of the TCLEQ

The Cronbach alpha reliability coefficient was used as an index of internal consistency in the study. An individual student and class mean score were used as the unit of analysis from a sample size of 721 students in 33 classes who participated in this study. The results reported in Table 4 show that the reliability coefficients for different TCLEQ scales (Cronbach alpha coefficient) ranged from 0.76 to 0.90 and from 0.85 to 0.95 for the Actual and Preferred Form, respectively, when using the individual as the unit of analysis. Figures ranged from 0.62 to 0.85 and from 0.63 to 0.85 for the Actual and Preferred Form, respectively, when using class as the unit of analysis. Five scales (Student Cohesiveness, Teacher Support, Investigation, Cooperation and Equity) had values which replicated those of previous studies by Aldridge and Fraser (1997), Chionh and Fraser (1998), Fraser and Aldridge (1998), Fraser, McRobbie and Fisher (1996), Rawnsley and Fisher (1997) and Rickards, Bull and Fisher (2001) for the WIHIC where the alpha reliability ranged from 0.77 to 0.93 for the Actual Form. However, the TCLEQ was modified from both the WIHIC and SLEI. Two more scales (Integration and Material Environment) were compared to the original or modified SLEI of four studies; Fraser, McRobbie and Fisher (1996), Henderson, Fisher and Fraser (1998), Riah and Fraser (1998) and Quek (2001), the results are also similar to those previous studies. All the figures well exceed the threshold of 0.60 set by Nunnally (1978) and 0.50 set by De Vellis (1991) as being an acceptable level of reliability for research purposes. Therefore, the Thai version of the TCLEQ, in both Actual and Preferred Forms, has satisfactory reliability for use in Thailand.

The discriminant validity of the TCLEQ was measured using one scale’s mean correlation with the other six scales for both Actual and Preferred Forms. When using the individual student as the unit of analysis the values ranged from 0.06 to 0.32 for the Actual Form and from 0.33 to 0.51 for the Preferred Form. When using the class mean as the unit of analysis, the values ranged from 0.26 to 0.40 for the Actual Form and from 0.24 to 0.61 for the Preferred Form. These values can be regarded as small enough to suggest that each scale of the TCLEQ has adequate discriminant validity, even though the scales measure somewhat overlapping aspects of the classroom environment. These results are similar to those returned in previous studies by Aldridge and Fraser (1997), Fraser, McRobbie, and Fisher (1996) and Rickards, Bull, and Fisher (2001) for the WIHIC, where the values ranged from 0.33 to 0.55 and by Fraser, McRobbie, and Fisher (1996), Henderson, Fisher, and Fraser (1998), Riah and Fraser (1998) and Quek (2001) for the SLEI, where the values ranged from 0.11 to 0.24. Therefore, the results presented in Table 4 suggest that each scale has satisfactory reliability and discriminant validity.

Table 4: Scale Internal Consistency (Cronbach Alpha Reliability), Discriminant Validity (mean correlation with other scales) and Ability to Differentiate Between Classrooms (ANOVA) for the Tertiary Chemistry Learning Environment Questionnaire (TCLEQ) in Rajabhat Institutes in Thailand

<table>
<thead>
<tr>
<th>Scale</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Discriminant Validity</th>
<th>ANOVA (eta2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Actual</td>
<td>Preferred</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Actual</td>
<td>Preferred</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>Individual</td>
<td>0.76</td>
<td>0.95</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.73</td>
<td>0.88</td>
<td>0.37</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Individual</td>
<td>0.82</td>
<td>0.86</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.67</td>
<td>0.77</td>
<td>0.38</td>
</tr>
<tr>
<td>Equity</td>
<td>Individual</td>
<td>0.90</td>
<td>0.91</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.78</td>
<td>0.92</td>
<td>0.40</td>
</tr>
<tr>
<td>Investigation</td>
<td>Individual</td>
<td>0.81</td>
<td>0.85</td>
<td>0.29</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.62</td>
<td>0.70</td>
<td>0.39</td>
</tr>
<tr>
<td>Integration</td>
<td>Individual</td>
<td>0.78</td>
<td>0.87</td>
<td>0.32</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.73</td>
<td>0.63</td>
<td>0.26</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>Individual</td>
<td>0.86</td>
<td>0.87</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.85</td>
<td>0.80</td>
<td>0.37</td>
</tr>
<tr>
<td>Material Environment</td>
<td>Individual</td>
<td>0.86</td>
<td>0.93</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.65</td>
<td>0.88</td>
<td>0.26</td>
</tr>
</tbody>
</table>

** p< 0.01     n = 721 students in 33 classes

Capability of differentiating between classrooms

In order to determine whether the TCLEQ scales can distinguish differences between classes, a one-way ANOVA with class membership as the main effect was calculated. Table 4 shows that each TCLEQ scale differentiated significantly (p< 0.01) between classes. The amount of variance explained by class membership is shown in the eta2 scores which ranged from 0.03 to 0.46. It appears that the instrument is able to differentiate
clearly between the perceptions of students from one class to another. These results are similar to those found by Fraser, McRobbie, and Fisher (1996), Henderson, Fisher, and Fraser (1998), Riah and Fraser (1998) and Quek (2001). Therefore, the instrument is able to distinguish between class groups their adding to its validity.

Reliability and validity of the TOCRA

The TOCRA instrument, modified from two scales of the TOSRA was used to investigate students’ attitudes toward chemistry. Table 5 shows the Cronbach alpha reliability values for the two scales of the TOCRA. When using the individual student as the unit of analysis, the alpha coefficients ranged from 0.78 to 0.83, and using the class mean as the unit of analysis, the alpha reliability coefficients ranged from 0.77 to 0.82.

Table 5: Scale Internal Consistency (Cronbach Alpha Reliability) and Discriminant Validity, of the TOCRA in Rajabhat Institutes in Thailand

<table>
<thead>
<tr>
<th>Scale</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Discriminant Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>Individual</td>
<td>0.83</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.82</td>
<td>0.38</td>
</tr>
<tr>
<td>Enjoyment of Chemistry Lessons</td>
<td>Individual</td>
<td>0.76</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.77</td>
<td>0.38</td>
</tr>
</tbody>
</table>

The discriminant validity of each scale again was determined by calculating the mean correlation of each scale with the other scale. The discriminant validity was 0.36 for both scale when using the individual student as the unit of analysis, and with the class mean as the unit of analysis, the discriminant validity was 0.38 for both scale. These figures indicate that the instrument has satisfactory, discriminant validity. These results of Adoption of Chemistry Attitudes scales and Enjoyment of Chemistry Lessons scale were similar to those of the studies of Riah and Fraser (1998) and Quek (2001).

Qualitative and quantitative methods

As Fraser and Tobin (1991), Webb, Campbell, Schwartz, and Sechrest (1966) and Webb, Campbell, Schwartz, Sechrest, and Grove (1981) suggested, the combination of qualitative and quantitative methods in learning environment studies can be considered noteworthy for several reasons, for example, the richness resulting from qualitative observational data complementing quantitative classroom environment data, and greater credibility of data obtained by the triangulation data collection method. Also, Yin (1994) supported issues of specification, that the qualitative method helped the researcher focus on the interesting issues, issues of immediate concern, and provide data that are ‘rich, detailed and insightful’. The qualitative methods involved in this study included classroom observation, student interviews, and teacher interviews.

Sample

The sample in this study consisted of 721 first-year students from 33 classes in Rajabhat Institutes in Thailand. These students were enrolled in the General Chemistry. There were 535 females and 186 males from 33 classes in the samples that responded to the TCLEQ and the TOCRA questionnaires. Six classes were observed and six instructors and 18 students were interviewed.

Data collection and analysis

The Thai versions of the TCLEQ and TOCRA questionnaires were administrated to 721 students in 33 classes. The observations and interviews were conducted. The instructors participated and gave feedback on the collected data.

Students’ perceptions of their learning environment

Table 6 indicates that for all seven of the scales of the TCLEQ there were significant differences between the actual and preferred scores, and that students preferred a more positive classroom environment than was actually present. The results are also illustrated in Figure 1. The greatest difference between the Actual and Preferred Forms was on the Integration scale. This suggests that students would prefer to have more proficiency in their knowledge or theoretical aspects and this should relate to their practical experiences. However, the largest standard deviations in the actual scales was in Integration (SD = 0.86) suggesting that students have very
different perceptions of their actual environment. But the preferred scale of Integration had the smallest standard deviation of 0.42 suggesting that the students' preferred views of Integration were very similar.

Table 6: Means and Standard Deviations for Students’ Actual and Preferred Learning Environments for the Scales of TCLEQ

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean (Actual/A)</th>
<th>Difference (P-A)</th>
<th>Standard Deviation</th>
<th>t-Test Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>4.16</td>
<td>0.47</td>
<td>0.47</td>
<td>0.53</td>
</tr>
<tr>
<td>Cooperation</td>
<td>4.03</td>
<td>0.54</td>
<td>0.57</td>
<td>0.51</td>
</tr>
<tr>
<td>Equity</td>
<td>4.00</td>
<td>0.49</td>
<td>0.72</td>
<td>0.62</td>
</tr>
<tr>
<td>Investigation</td>
<td>3.07</td>
<td>0.90</td>
<td>0.62</td>
<td>0.67</td>
</tr>
<tr>
<td>Integration</td>
<td>2.40</td>
<td>2.30</td>
<td>0.86</td>
<td>0.42</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>3.08</td>
<td>1.04</td>
<td>0.75</td>
<td>0.71</td>
</tr>
<tr>
<td>Material Environment</td>
<td>4.05</td>
<td>0.39</td>
<td>0.79</td>
<td>0.60</td>
</tr>
</tbody>
</table>

* p <0.05     n = 721

Gender differences in students’ perceptions of their learning environment

Table 7 shows that male students perceived differences in all seven scales of the TCLEQ. It indicates that male students prefer a more positive learning environment than that which they perceive to be present. This finding is profiled in Figure 2. It is clear that male students’ and female students’ perception, both on the Actual and the Preferred Form, were similarly. This result suggests that both male students and female students were encouraged and participated in their classes and were treated in a similar manner.

Table 7: Means and Standard Deviations scores for the Actual and Preferred Form of the TCLEQ for Male and Female students

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Difference</th>
<th>t-test Values</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male (M)</td>
<td>Female (F)</td>
<td>(M-F)</td>
<td></td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>Actual</td>
<td>4.13</td>
<td>4.16</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.47</td>
<td>4.67</td>
<td>-0.20</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.50</td>
<td>-0.92</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>Actual</td>
<td>3.98</td>
<td>4.05</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.45</td>
<td>4.61</td>
<td>-0.17</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.64</td>
<td>-0.87</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>Actual</td>
<td>4.01</td>
<td>4.00</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.43</td>
<td>4.50</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.52</td>
<td>-0.60</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>Actual</td>
<td>3.20</td>
<td>3.04</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>3.88</td>
<td>4.00</td>
<td>-0.12</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.89</td>
<td>-1.23</td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>Actual</td>
<td>2.35</td>
<td>2.41</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.57</td>
<td>4.70</td>
<td>-0.13</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-2.32</td>
<td>-2.62</td>
<td></td>
</tr>
<tr>
<td>Teacher Support</td>
<td>Actual</td>
<td>3.19</td>
<td>3.04</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.02</td>
<td>4.16</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.92</td>
<td>-1.24</td>
<td></td>
</tr>
<tr>
<td>Material Environment</td>
<td>Actual</td>
<td>4.03</td>
<td>4.06</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>4.34</td>
<td>4.48</td>
<td>-0.14</td>
</tr>
<tr>
<td></td>
<td>Effect Size</td>
<td>-0.35</td>
<td>-0.47</td>
<td></td>
</tr>
</tbody>
</table>

* p <0.05     n = 721
Both male students and female students preferred more of all aspects measured by the learning environment scales. However female students’ perceptions were greater than male students on six of the seven learning environment scales, Student Cohesiveness, Cooperation, Investigation, Integration, Teacher Support and Material Environment. The Equity scale is the exception where there was no statistically significant difference between male and female students. This suggests that they were treated equally by their instructor and qualitative information were confirmed.

Gender differences in attitudes toward chemistry

Male and female students’ attitudes toward chemistry were explored and compared by students’ mean scores for each attitudinal scale and t–test statistic figures were calculated and use to examine gender differences. The mean scores of the scales of the TOCRA, standard deviations and t-test results are shown in Table 8

The mean scores for Adoption of Scientific Attitudes for both male students and female students were 4.0 and 3.9, respectively. This indicates that students’ believe they do adopt scientific attitudes. Whilst there were statistically significant differences between male students and female students, the effect size is only small. Also, the mean score for Enjoyment of Chemistry Lessons for both male students and females students were 3.57 and 3.46, respectively, indicating that students’ were enjoying their chemistry lessons. Again, there was a significant difference between the genders but small magnitudes in effect sizes.

These findings indicate that both male and female students adopted scientific attitudes in their chemistry classes. The findings also indicated that all students enjoyed their classes; male students enjoyed their classes slightly more than did female students.
Table 8: Comparison of Mean, Standard Deviation, Mean Differences and Effect Sizes for the Attitudinal Measures Based on the Gender of Students in Rajabhat Institutes in Thailand

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean Difference</th>
<th>Standard Deviation</th>
<th>t-test Values</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adoption of Scientific Attitudes</td>
<td>Male (M) 4.00</td>
<td>Female (F) 3.90</td>
<td>(M-F) 0.10</td>
<td>Male (M) 0.32</td>
</tr>
<tr>
<td>Enjoyment of Chemistry Lessons</td>
<td>Male (M) 3.57</td>
<td>Female (F) 3.46</td>
<td>(M-F) 0.11</td>
<td>Male (M) 0.39</td>
</tr>
</tbody>
</table>

* p <0.05   n = 721

Classroom Observations and Interview Results

In general, at the tertiary level, students have been exposed mainly to traditional lecture style or teacher-directed instruction. From classroom observation, it could be stated that active-learning and student-centred instructional approaches were used by the instructors. They provided the students with a variety of teaching-learning activities. There were no longer truly traditional lectures but there was a combined variety of teaching techniques to constitute active lecturing. The students were encouraged to engage in discussion, to share experiences, to participate in all activity, and to answer questions or to solve problems together.

During the laboratory sessions while the students were actively engaged in experiment, the instructors facilitated and demonstrated some issues and techniques in a friendly, non-threatening manner that did not imply correct or wrong student activity. It was found they could get along easily with each other. Therefore, they were satisfied with their learning environment, enjoying it, acting with growing confidence, and having a good attitude toward this subject of study. Of course, these findings have been confirmed by many researchers (Chilcoat, 1989; Gibbs, Habeshaw and Habeshaw, 1992; Sutton, 2003): that active lecturing stands alongside other successful interactive learning methods for transmitting information. The pleasing result in classes observed in this study of a more cordial and active participation learning atmosphere was supported by the questionnaire data interpretation.

It was observed during this study, and through the interviews that the students diligently attended to all learning activities in order to follow and complete all lecture and laboratory requirements, but they were not truly comprehending or insightful yet. The large amounts of prescribed knowledge and practical work could not be integrated successfully, leaving them with inferior learning skills. Laboratory-directed experiments were assigned where the students were asked to follow a set of instructions but there were few exercises and activities that could encourage students to investigate. Many reasons for this were supplied from students’ interviews such as the huge block of theoretical knowledge to learn, the perceived difficulty of the subject and the laboratory-directed sessions that did not allow for students to do other than the set procedure.

The students were becoming aware that the learning environment was important and that their skills were inferior. They expressed their need and desire for more interaction, facilitative learning and peer reciprocation. In particular in practical sessions, they needed more experiments and experiences that enable them to develop investigation and integration skills. Findings from student interviews on the preference for more integration of theory and practical work was complemented by the instructors’ interviews who responded that there were only a few opportunities for students to create, to find out what they wanted to learn, and what they have learned.

From this study it could be affirmed that classroom observation incorporated with student and instructors’ interviews are valuable tools for the investigation and interpretation of learning environments. This is supported by Fraser and Tobin (1991), that the utilisations of qualitative and quantitative data together paint a more compelling picture of the learning environments.

Significance of the study

This study provides the first reported findings of student perceptions of classroom environment, and students’ attitudes to learning chemistry in Rajabhat Institutes in Thailand. The study is significant for five reasons; it is likely to provide new information about students' perceptions of learning environments in Rajabhat Institutes; it is likely to provide information about students' attitudes to learning chemistry in Rajabhat Institutes; it validates
the learning environment assessing instruments (TCLEQ) and the Attitude to Science scale in chemistry classrooms (TOCRA) in Rajabhat Institutes; it provides information on associations between students' perceptions of classroom environment and their attitudes to learning chemistry in Rajabhat Institutes. Finally, the combination of quantitative and qualitative methods provide a good description of tertiary chemistry classrooms in Thailand and this could lead to an improvement in the teaching and learning processes in these classrooms.

In this study, it seems that students' proficiency in investigation and students' capability for integration are two of the important objectives towards which students must be practiced and trained. But, students scored poorly on the investigation and integration scales. It seemed that chemistry teaching and learning was laboratory-directed and teacher-directed. The students tended to limit themselves to follow and finish laboratory manuals and set exercises. Not only that, but it was found there were few teaching-learning activities that encouraged students to perform investigation into chemistry. Therefore it is becoming imperative for instructors to adjust and alter their instructional approach to provide a more suitable timeframe and scope for their students. The suggestions are confirmed by Hotchkis (1995) that learning should involve the investigation of learning content, procedures and problems. Students should be given opportunities to discover and create procedures, to describe and record relationships contained, and to solve problems in the lessons as they learn.

By using the Actual and Preferred Forms of the questionnaire, students are given a real picture of their classroom situation. Similar to other students in Asia, Thai students are neither keen nor trained to speak up in a formal setting. Most prefer to just stay quiet, let other people take the limelight, and be modest (Chong Chi Tat, 1999). Therefore, the results given by students from the questionnaires is one superior way for students to feel free to express their real situation and what they feel they need in their classes. Consequently, as a result of having both Actual and Preferred Forms, this instrument gives information that encourages the instructors to take action for the sake of a better learning environment for their students.

References


ABSTRACT

This paper presents an evaluation of a computer classroom psychosocial learning environment and investigation of associations between learning environment factors and students’ attitudes at the tertiary level in Thailand. Both quantitative and qualitative methods were used in this study. Three questionnaires were employed to provide quantitative data: the College and University Classroom Environment Inventory (CUCEI), the Computer Laboratory Environment Inventory (CLEI), and the Attitude towards Computer and Computer Courses (ACCC). The sample consists of 905 computer science students. Overall, the results generated from scale internal reliability analysis, mean correlations and ANOVAs suggested that the modified Thai versions of the CUCEI, CLEI, and ACCC are valid and reliable instruments for measuring students’ perceptions of computing laboratory learning environments in a Thailand University. The students had positive perceptions about their computer classroom learning environment. The qualitative data obtained from student interviews supported the information from questionnaires and provided more detail about the computer classrooms. Regarding associations between students’ attitudes and perceptions of the computer classroom, most scales of the Thai CUCEI and CLEI, were statistically significantly positively associated with the four scales of the Thai version of the ACCC. Importantly, there were significant negative correlations between scales of the CWCEI and CLEI with the Anxiety scale.

INTRODUCTION

The classroom psychosocial environment plays a significant role in determining the learning process (Walberg, 1981). It is a strong predictor of both achievement and attitude outcome (Fraser, 1998a, 1998b), so educational quality promotion requires developing positive classroom learning. Having a positive learning environment is not only valuable in its own right but it also leads to highly valued improvements in student achievement (Walberg, 2002). Many researchers agree with Walberg, they claim that positive learning environments have to be created to enhance student’s satisfaction, engagement in learning, and academic achievement (Ames, 1992; Candy, Crebert, & O’Leary, 1994; Ramsden, Margetson, Martin, & Clarke, 1995). Instructors who consider creating a positive learning environment must be supportive of all students and respect the diversity of languages, cultures, values, and attitudes, which they bring into the classrooms. Students who feel they belong to the class will be more at ease, enthusiastic and willing to become actively involved in learning.

Teaching computer courses in schools, colleges, and universities in Thailand is arranged in classrooms and laboratories. In regular classrooms, teachers tend to organize or manage learning activities and students themselves tend to receive the lessons from teachers. Teachers’ planning for classes is the frame within which activities are shaped. Students’ roles, however, tend to be passive if traditional methods are used but may become active if the teachers plan more innovative lessons. Teachers and students interact at some level and this interaction becomes a factor that helps create a learning environment. Researchers pay much attention to finding ways to get positive interactions in classrooms. Positive interaction makes students happy while negative interactions do not. Teachers normally like their students to feel happy in class so they are likely to enhance happiness, and therefore learning, for their students. Teachers need to receive feedback from students in class and assess their own behaviours in order to create a good learning environment as well as happy lessons. This feedback can help teachers reflect and improve their teaching and classroom management.

In laboratories, students need to learn through hands-on practice and experimentation. Theory will be applied in the laboratories. Equipment and software are part of the environment and steps of learning and teaching in laboratories must be well planned. That is, students interact with equipment, software, theories, other students and teachers. In laboratories, students mainly concentrate on getting the experiments or tasks done. The environment in laboratories involves many more factors than those in regular classrooms.

Education processes that can lead to competent computing studies involve several key factors. First, curriculum, methods of teaching, materials, and facilities must be considered. Secondly, relationships between
instructors and students as well as learning environments are main issues for consideration. Thirdly, students’ perceptions need to be ascertained so that teachers can gain guidance and information about their classrooms.

**THEORETICAL FRAMEWORK FOR CLASSROOM LEARNING ENVIRONMENT**

Instruments for assessing the classroom psychosocial environment environments are based on the three dimensions proposed by Moos (1976). These are Relationship Dimension, Personal Development Dimension, and System Maintenance and System Change Dimension. The Relationship Dimension assesses the extent to which people are involved in the setting, support and help each other, and express themselves freely and openly. Examples of this dimension are the extent of student involvement and cohesiveness with other students (Moos, 1979, p. 14). The Personal Development Dimension assesses the basic directions along which personal growth and self-enhancement tend to occur in the particular environment (Moos, 1976, p. 331). Examples of this are task orientation and competition. The System Maintenance and System Change Dimension assess the extent to which the environment is orderly and clear in its expectations, maintains control and responds to change (Moos, 1979, p. 16). Examples of this are orderliness, organization and innovation.

For important developments with learning environment instruments, most of instruments were developed into two forms. They have not only a form to measure perceptions of actual classroom environment, but also another form to measure perceptions of preferred classroom environment. The Preferred Form is concerned with goals and value orientations and measures perceptions of the classroom environment ideally liked (Fraser, 1998a). The differences between students’ perception of the actual and preferred classroom learning environment can be useful information to guide teachers in creating a more positive leaning environment.

**METHOD**

This study involved the use of three questionnaires, the Personal Form of the College and University Classroom Environment Inventory (CUCEI) which had been developed by Nair and Fisher (1999), the Computer Laboratory Environment Inventory (CLEI) and the Attitude towards Computers and Computer Courses (ACCC) developed by Newby and Fisher (1997) to examine the learning envirnments of computer classrooms and students’ attitudes towards computing courses in universities in Thailand. The sample consisted of 905 computer science major students in 33 classrooms from 11 universities. A combination of quantitative and qualitative approaches was used. In the quantitative method, three questionnaires were employed. Qualitative data were obtained from interviews with students.

**RESULTS**

Reliability and validity of the three instruments

Table 1 shows the alpha reliabilities, mean correlations with other scales and $\eta^2$ for two units of analysis of the CUCEI Actual Form. The alpha reliabilities ranged from 0.56 to 0.96. Four scales, namely, Personalization, Student Cohesiveness, Cooperation, and Equity have reliabilities of more than 0.80. Two scales, Innovation and Task Orientation, are reasonably acceptable, with modest scores of 0.72 and 0.62, respectively. The Individualization scale has the lowest alpha reliability score but is acceptable at 0.56. The discriminant validity scales ranged from 0.14 to 0.33 when the individual student was used as the unit of analysis, and from 0.14 to 0.52 when the class mean was utilized as the unit of analysis. The $\eta^2$ were all significant and ranged from 0.09 to 0.18.

For the CUCEI Preferred Form, the Cronbach alpha coefficients ranged from 0.56 to 0.87 and from 0.56 to 0.97, when the individual score and class means were used as the unit of analysis, respectively. The mean correlations ranged from 0.33 to 0.43 when using the individual score as the unit of analysis. The $\eta^2$ values ranged from 0.09 to 0.21 as show in Table 2.
### Table 1
**Internal Consistency Reliability (Cronbach Alpha Coefficient), Mean Correlations and Eta² for Two Units of Analysis of the CUCEI Actual Form (N = 905)**

<table>
<thead>
<tr>
<th>Scales</th>
<th>Number of items</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Mean Correlation</th>
<th>ANOVA (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalisation</td>
<td>7</td>
<td>Individual</td>
<td>0.81</td>
<td>0.33</td>
<td>0.10***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.89</td>
<td>0.48</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>6</td>
<td>Individual</td>
<td>0.72</td>
<td>0.17</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Class</td>
<td>0.66</td>
<td>0.30</td>
<td></td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>7</td>
<td>Individual</td>
<td>0.81</td>
<td>0.14</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.95</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>Task Orientation</td>
<td>7</td>
<td>Individual</td>
<td>0.62</td>
<td>0.33</td>
<td>0.18***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.85</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>7</td>
<td>Individual</td>
<td>0.88</td>
<td>0.28</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.96</td>
<td>0.39</td>
<td></td>
</tr>
<tr>
<td>Individualisation</td>
<td>6</td>
<td>Individual</td>
<td>0.56</td>
<td>0.16</td>
<td>0.12***</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Class</td>
<td>0.56</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>7</td>
<td>Individual</td>
<td>0.89</td>
<td>0.33</td>
<td>0.09***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.92</td>
<td>0.52</td>
<td></td>
</tr>
</tbody>
</table>

***p<0.001

### Table 2
**Internal Consistency Reliability (Cronbach Alpha Coefficient), Mean Correlations and Eta² for Two Units of Analysis of the CUCEI Preferred Form (N = 905)**

<table>
<thead>
<tr>
<th>Scales</th>
<th>Number of items</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Mean Correlation</th>
<th>ANOVA (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personalisation</td>
<td>7</td>
<td>Individual</td>
<td>0.71</td>
<td>0.34</td>
<td>0.16***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.84</td>
<td>0.69</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>6</td>
<td>Individual</td>
<td>0.57</td>
<td>0.35</td>
<td>0.11***</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Class</td>
<td>0.88</td>
<td>0.58</td>
<td></td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>7</td>
<td>Individual</td>
<td>0.75</td>
<td>0.37</td>
<td>0.21***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.90</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Task Orientation</td>
<td>7</td>
<td>Individual</td>
<td>0.70</td>
<td>0.43</td>
<td>0.17***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.97</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>7</td>
<td>Individual</td>
<td>0.87</td>
<td>0.42</td>
<td>0.12***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.93</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Individualisation</td>
<td>6</td>
<td>Individual</td>
<td>0.56</td>
<td>0.33</td>
<td>0.10***</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>Class</td>
<td>0.85</td>
<td>0.61</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>7</td>
<td>Individual</td>
<td>0.85</td>
<td>0.39</td>
<td>0.09***</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>Class</td>
<td>0.93</td>
<td>0.71</td>
<td></td>
</tr>
</tbody>
</table>

***p<0.001
Table 3 shows that the Cronbach alpha coefficients ranged from 0.61 to 0.75 if the individual student score was used as the unit of analysis and ranged from 0.61 to 0.75 if the class means were used. Five scales of the CLEI, namely, Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy and Laboratory Availability were above 0.68. The Open-Endedness scale possessed the lowest score of 0.61. The discriminant validity for the CLEI scales as shown by the mean correlation scores ranged from 0.33 to 0.41 when the individual student was used as the unit of analysis and from 0.53 to 0.59 when the class mean was employed. The \( \eta^2 \) scores were again significant and ranged from 0.09 to 0.22.

### Table 3

<table>
<thead>
<tr>
<th>Scales</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Mean Correlation</th>
<th>ANOVA (( \eta^2 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>Individual</td>
<td>0.73</td>
<td>0.37</td>
<td>0.20***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.92</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>Individual</td>
<td>0.61</td>
<td>0.35</td>
<td>0.09***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.61</td>
<td>0.53</td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>Individual</td>
<td>0.61</td>
<td>0.33</td>
<td>0.20***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.85</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Technology Adequacy</td>
<td>Individual</td>
<td>0.68</td>
<td>0.41</td>
<td>0.16***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.83</td>
<td>0.59</td>
<td></td>
</tr>
<tr>
<td>Laboratory Availability</td>
<td>Individual</td>
<td>0.75</td>
<td>0.33</td>
<td>0.22***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.92</td>
<td>0.56</td>
<td></td>
</tr>
</tbody>
</table>

*** \( p<0.001 \)

Table 4 shows that the alpha reliability of the ACCC scales scores are relatively high, ranging from 0.64 to 0.72 when the individual student was used as the unit of analysis, and from 0.77 to 0.89 when the class means were employed as the unit of analysis. The discriminant validity ranged from 0.18 to 0.51 when the individual student was used as the unit of analysis. When the class means were utilized as units of analysis, the mean correlation scores ranged from 0.24 to 0.29 for all scales, except for the Anxiety scale that had a score of 0.80. The \( \eta^2 \) were significant with a range from 0.14 to 0.15.

### Table 4

<table>
<thead>
<tr>
<th>Scales</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>Mean Correlation</th>
<th>ANOVA (( \eta^2 ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Usefulness Course</td>
<td>Individual</td>
<td>0.64</td>
<td>0.18</td>
<td>0.15***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.87</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td>Individual</td>
<td>0.72</td>
<td>0.51</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.89</td>
<td>0.80</td>
<td></td>
</tr>
<tr>
<td>Usefulness Computers</td>
<td>Individual</td>
<td>0.66</td>
<td>0.18</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.77</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td>Individual</td>
<td>0.70</td>
<td>0.25</td>
<td>0.14***</td>
</tr>
<tr>
<td></td>
<td>Class</td>
<td>0.84</td>
<td>0.24</td>
<td></td>
</tr>
</tbody>
</table>

*** \( p<0.001 \)
Students’ perceptions toward their computer classroom learning environment

The data from questionnaires

For students’ perceptions toward their computer classroom learning environment, the data from the questionnaires revealed that students possessed a positive view of their computer classroom learning environments (Table 5 and Figure 1). The mean scores for all scales were higher than 3.00 for both actual and preferred learning environments with the exception of the actual Individualisation scale which was 2.90. These scores indicate that students generally experience the activities referred to in the questionnaire.

Results from t-tests for paired samples showed that actual preferred differences were statistically significant (mostly p<0.001) on all scales. The results, which are consistent with previous studies (Nair & Fisher, 2000), suggest that most students would prefer a learning environment which is characterised by having more personalisation, enhancing students’ cohesiveness, providing clearer task orientation, doing more investigations, allowing individuality but also ensuring greater cooperation as well as more equity during class sessions. Teachers or principals can use these differences in both actual and preferred scales as a focus for improving the classroom learning environment in keeping with Fraser's (1989) five stages for learning environment enhancement.

Table 5
Average Item Means, and Standard Deviations of Students’ Perceptions of Actual and Preferred Forms of the CUCEI

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-test on Mean diff.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Preferred</td>
<td>Actual</td>
</tr>
<tr>
<td>Personalisation</td>
<td>3.27</td>
<td>3.78</td>
<td>0.64</td>
</tr>
<tr>
<td>Innovation</td>
<td>3.27</td>
<td>3.50</td>
<td>0.53</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>3.99</td>
<td>4.04</td>
<td>0.73</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>3.35</td>
<td>3.90</td>
<td>0.52</td>
</tr>
<tr>
<td>Cooperation</td>
<td>3.70</td>
<td>3.98</td>
<td>0.65</td>
</tr>
<tr>
<td>Individualisation</td>
<td>2.90</td>
<td>3.37</td>
<td>0.46</td>
</tr>
<tr>
<td>Equity</td>
<td>3.34</td>
<td>3.79</td>
<td>0.69</td>
</tr>
</tbody>
</table>

***p<0.001, **p<0.01, *p<0.05  n=905

Figure 1. Comparisons between students’ perceptions of actual and preferred computer science classroom learning environments.
The data from interviews

The qualitative methods involved interviewing; two students who volunteered to be interviewed. The interviews were open-ended and guided by an interview protocol which focused on each scale of the Thai version of the CUCEI, namely, Personalisation, Innovation, Student Cohesiveness, Task Orientation, Cooperation, Individualisation, and Equity.

The interview results also show that generally the students are satisfied with their instructor’s personal support. They commented that the instructor considers students’ feelings, for example:

- *I know my instructor is concerned about my feelings. She often asks me, have you any questions, what part don’t you understand? (IS 16.1)*

Regarding the Innovation scale, students provided various positive comments:

- *My instructor created an WBI (web based instruction lesson) for this course. I am comfortable to learn with WBI any time I want and I have no need to take notes when I listen to the lecture. I can print out the material easily (IS11.1)*

On the Task Orientation scale, students believed class activities were carefully planned as they typically said:

- *I know well what activity is included for this class, because my instructor gave me a course description which has a lot of detail about the teaching and learning activities provided in this class. (IS 28.1)*

The students’ perceptions regarding the Cooperation scale, students stated that cooperation with other classmates was important and useful, and the instructor often asked the students to work cooperatively:

- *My instructor lets my classmates and I work as a group. It is helpful. We can share many important ideas, it is an excellent experience, and I can learn more with clever friends. (IS 9.1)*

In relation to the Student Cohesiveness scale, students felt they knew each other well. They provided various comments like:

- *My classmates and I have studied in the same major for over one year. I know all of my classmates’ names but only a few are my close friends. (IS 5.1)*

For the Individualisation scale, students generally felt that they had opportunities to follow their own interests:

- *I have the opportunity to pursue my own interests. I enjoy working by myself. Sometimes I was terrible, and had no idea how to solve the problems, I tried to relax, and went away from my project for a while. Finally I could solve it. I was so proud of my success and felt that oh I could do it. (IS 15.1)*

However, there were a few comments that they were required designed to do the same kind of assignment and project:

- *I was allowed to do the same kind of assignments as my classmates. I felt happy about this, since if I had some problems with doing the assignment I could look at my friends’ works. (IS 4.1)*

Most comments showed that the students agreed that they were treated equally by the lecturer:

- *The instructor always yields to students who make a mistake and compliment good students fairly. (IS 9.1)*

Again there were very few negative comments stated such as:

- *The instructor is interested in asking questions to the clever students more than to me. (IS 17.1)*

The results from these interviews with students provided the ability to scrutinize in more detail the students’ perceptions towards their computer classroom learning environments. Both the questionnaire and the interview data confirmed that many students have satisfactory perceptions of their computer classroom learning environments.
Students’ perceptions of their computer laboratory learning environment

Figure 2 shows that students hold positive views about their computer laboratory learning environment. The mean scores for all scales are higher than 3.00 (maximum 5.00), with the exception of the Availability scale. These scores indicate that the Thai university computer laboratory has provided the students with a relatively positive learning environment.

Figure 2. Students’ perceptions of the Computer Laboratory Environment Inventory (CLEI).

Figure 3 shows that Thai university students value computers as important tools and view computer courses as a significant subject for their future careers. These findings are indicated by the scores on the scales of Usefulness of Computers and Usefulness of Course, which are 3.77 and 3.41, respectively. These scores are in accordance with the students’ view toward enjoyment of their computer courses. The Enjoyment scale has the highest score of all the scales. In general, these results show that currently computer courses in this sample of Thai Universities are viewed as important subjects and need to be maintained. On the other hand, despite these positive views, this study also revealed that some students might experience a little anxiety during their computer course and when using the computer.

Figure 3. Students’ attitudes towards computers and computer courses.
Association Between Computer Classroom Learning Environment Scales and Student Attitudinal Outcomes

Table 6 shows that all scales of the Thai CUCEI, with the exception of the Individualisation scale, are statistically significantly (p<0.01) associated with the four scales of the Thai version of the ACCC. The Individualisation scale is statistically significant and positively associated with the Usefulness of Course: however, it is negatively associated with the Usefulness of Computer scale. A significant negative correlation exists between the five scales of the Thai CUCEI and the Anxiety scale. Apparently, Innovation and Individualisation have no impact on student anxiety level.

Table 6

Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β) for Association Between Computer Classroom Learning Environment Scales and Student Attitudinal Outcomes

<table>
<thead>
<tr>
<th>Scale</th>
<th>Strength of environment-outcome association</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Usefulness of Course</td>
</tr>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td>Ps</td>
<td>0.26**</td>
</tr>
<tr>
<td>Inn</td>
<td>0.10**</td>
</tr>
<tr>
<td>SC</td>
<td>0.24**</td>
</tr>
<tr>
<td>TO</td>
<td>0.25**</td>
</tr>
<tr>
<td>Co</td>
<td>0.30**</td>
</tr>
<tr>
<td>Ind</td>
<td>0.14**</td>
</tr>
<tr>
<td>Eq</td>
<td>0.31**</td>
</tr>
<tr>
<td>R</td>
<td>0.40***</td>
</tr>
<tr>
<td>R'</td>
<td>0.16***</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001
Associations between Computer Laboratory Learning Environment and Student Attitudinal Outcomes

Table 7 indicates that the five scales of the Thai version of the CLEI are statistically significant with respect to the four scales of the Thai version of the ACCC.

Table 7
Simple Correlation (r), Multiple Correlation (R) and Standardised Regression Coefficient (β) for Associations Between Computer Laboratory Learning Environment and Student Attitudinal Outcomes

<table>
<thead>
<tr>
<th>Strength of environment-outcome association</th>
<th>Usefulness of Course</th>
<th>Anxiety</th>
<th>Usefulness of Computer</th>
<th>Enjoyment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scale</td>
<td>r</td>
<td>β</td>
<td>r</td>
<td>β</td>
</tr>
<tr>
<td>SC</td>
<td>0.40**</td>
<td>0.19***</td>
<td>-0.30**</td>
<td>-0.20***</td>
</tr>
<tr>
<td>OE</td>
<td>0.38**</td>
<td>0.19***</td>
<td>-0.17**</td>
<td>-0.01</td>
</tr>
<tr>
<td>INT</td>
<td>0.43**</td>
<td>0.26***</td>
<td>-0.35**</td>
<td>-0.26***</td>
</tr>
<tr>
<td>TA</td>
<td>0.31**</td>
<td>0.14***</td>
<td>-0.17**</td>
<td>-0.09*</td>
</tr>
<tr>
<td>AV</td>
<td>0.13**</td>
<td>-0.11*</td>
<td>0.15***</td>
<td>-0.06</td>
</tr>
<tr>
<td>R</td>
<td>0.54***</td>
<td>-0.41***</td>
<td>0.44***</td>
<td>0.46***</td>
</tr>
<tr>
<td>R²</td>
<td>0.29***</td>
<td>-0.17***</td>
<td>0.19***</td>
<td>0.21***</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001

DISCUSSION

This research confirms the validity of the three questionnaires, the CUCEI, the CLEI and the ACCC which can therefore be employed in the Thailand university context. The instructors, administrators and educational researchers can use these instruments for investigating students’ perceptions of their classroom learning environments and attitudes with confidence. The research results not only demonstrated the whole view of students in psychosocial learning environments of computer science curriculum in Thailand but also revealed that there are differences between students’ perceptions of their actual and preferred learning environments. Thus improving computer classroom learning environment in universities in Thailand should be considered, to bring the actual perception closer to the preferred one. The results also indicated that the computer classroom learning environments are associated with students’ attitudes. Therefore, instructors can improve students’ attitudes and as a consequence their cognitive achievement, by improving their learning environments.

REFERENCES


Studens’ Perceptions of Their Learning Environments and Outcomes in Mathematics and Statistics Classrooms at Rajabhat Universities in Thailand

Charoen Chantavong
Udon Thani Rajabhat University

Abstract

The purposes of this study were first, to assess students’ perceptions of their classroom environment in mathematics and statistics classrooms at Rajabhat Universities in Thailand using modified and validated versions of the Questionnaire on Teacher Interaction (QTI) and the College and University Classroom Environment Inventory (CUCEI); second, to gauge students’ attitude toward mathematics and statistics using an abbreviated version of the Test of Science-Related Attitude (TOSRA); third, to investigate associations between students’ learning environments, their attitudes toward mathematics and statistics as a subject, and their cognitive achievement scores, and last to investigate any differences between male and female students on their perceptions of their classroom in mathematics and statistics classes using the QTI and CUCEI. This study is significant because it is one of the first to use learning environment instruments to gauge students’ perceptions of their learning environment in mathematics and statistics classrooms at Rajabhat Universities in Thailand. As a result, these instruments are now available and can be used by teachers to monitor what is occurring in their classrooms and thus guide improvements in their teaching, thereby leading to improve learning at Rajabhat Universities in Thailand.

Background

This study focuses on the classroom learning environment of the students in mathematics and statistics classrooms at Rajabhat Universities in Thailand.

The Rajabhat Universities are similar to other state universities in Thailand which provide higher education in the country. It is composed of 40 universities distributed across the five areas of Thailand: the northern, the northeastern, the southern, the central, and Bangkok zone. All Rajabhat Universities offer students courses in Diploma, Bachelor’s degree, Master’s degree, and Doctoral degree in four academic areas: the pure science, social science and humanities, management science, and education.

The students of the universities come from secondary schools for the Bachelor’s degree and their ages range from seventeen onwards. They enroll in the first semester around June each year and study for at least two years for Diploma, four years for a Bachelor’s degree and two years for a Master’s degree. There are various programs they can choose, such as Applied Statistics, Mathematics, General Management, Computer Science, Drama, Chemistry, Biology, Physics and so on. All students have to enroll in one course in mathematics and statistics, such as Principles of Statistics, Statistics for Research, Thinking and Decision Making, and Business Statistics. The courses which the author has taught include Principles of Statistics, Business Statistics, Statistics for Research, Calculus, and Thinking and Decision Making.

The classroom learning environments in the Rajabhat Universities, as in other universities elsewhere in Thailand, has not yet been the subject of study, although past researches have shown that the learning environments in classrooms affect the learning outcomes of students (Fraser & Walberg, 1981; Fraser & Fisher, 1982; Fraser, 1986). So, in this study I have concentrated on the learning environment in the classrooms, using students in mathematics and statistics classes at Rajabhat Universities as a sample. Two instruments – the Questionnaire on Teacher Interaction (QTI) and the College and University Classroom Environment Inventory (CUCEI) were used to measure students’ perceptions of their classroom environments in mathematics and statistics classrooms. The other two instruments – the TOSRA (in scales Attitude Towards Subjects) and the Questionnaire on Teacher Interaction: Teacher Self Questionnaire – were used to assess students’ perceptions about learning environments and to measure teachers’ perceptions of their behaviours in mathematics and statistics classes respectively.

Teh and Fraser (1993) investigated the associations between the outcome-environment and a Computer-Assisted Learning (CAL) environment in geography classes with a sample of 671 students using the Geography Classroom Environment Inventory (GCEI). The results of this study showed that there were associations between student outcomes and the nature of classroom environment and confirmed the findings past of researches that both achievement and attitudes were enhanced by positive environment of all scales assessed, namely, Gender Equity, Innovation, Investigation, and Resource Adequacy.
In Thailand there have been few studies in classroom learning environment, especially in the Rajabhat Universities. Most teachers focus on the content of subjects and methods of teaching, but neglect the classroom environments. Past and present researchers have shown that positive classroom learning environments lead to higher achievement among students (Haertel & Walberg, 1988).

THE RAJABHAT UNIVERSITIES CONTEXT

To place this study in context I review here the geographical locations of the Rajabhat Universities in Thailand; the Rajabhat University Council (RUC); the Rajabhat University Curriculum and the approach to teaching adopted in the Rajabhat Universities.

Geographical locations of Rajabhat Universities in Thailand

The 40 Rajabhat Universities are located in five areas in Thailand: the northern, the northeastern, the southern, the central, and Bangkok zone. Eight operate in the northern province; 12 in the northeastern; 5 in the southern; 8 in the central; and 7 in Bangkok. These Rajabhat Universities, established by the "Rajabhat Universities Act, B.E. 2547(2004)" (Government Gazette, 2005) in June 10, 2004, offer students one Diploma and three kinds of degrees: Bachelor’s degree, Master’s degree and Doctoral degree.

Rajabhat University Council (RUC)

The administrative structure and system of the Rajabhat Universities are organized and oriented to fulfill its mission and goals. In summary, the 40 Rajabhat Universities are controlled by the Ministry of Education and administered by the “Higher Educational Committee”. Each Rajabhat University organizes by Rajabhat University Council (RUC), Rajabhat University Academic Committee Council, and Faculty and Official Council. The head of the university is the president approved by the RUC. The administrations of the university are divided into faculties or the unit of work. There are at least 4 faculties in each university; faculty of science, faculty of technology, faculty of management science and faculty of education.

Rajabhat University Curriculum and Teaching Approach

The board of each university can devise its own curriculum. There are three curriculum branches: Education, Science, and Art. Education contains programs: Primary Education, Secondary Education, Thai, and Mathematics; Science contains programs of Agriculture, Food Science, Applied Statistics, Computer Science; Art contains programs of English, Community Development, Drama, Business Management, and General Management.

The teaching approach in 40 Rajabhat Universities is almost identical. Instruction is the teacher-centred, during which teachers stand in front of the class each period, begin a lesson, write on the blackboard and the students listen. At the end of a period the teacher gives students some exercises to complete. There may be a few students who want to ask some questions, however there is little chance for the teachers (instructors) to talk with individuals because some classes are large (about 40-50 students in some class). A number of students desire only high grades in the final test; they often feel that they have no need for more knowledge or a new information from the teacher. Among the students of mathematics and statistics, 10% passed the final examination with high grades; 30% with medium grades and of 60% with the poor grades. The number of students who obtained poor grades motivated the author to learn more about the learning environment in mathematics and statistics classrooms in order to overcome this poor situation.

RESEARCH QUESTIONS

1. Is the modified QTI a valid and reliable instrument to assess students’ perceptions of their teachers’ behaviours in mathematics and statistics classrooms at Rajabhat Universities in Thailand?
2. Is the modified CUCEI a valid and reliable instrument to assess the students’ perceptions of their classroom environments in mathematics and statistics classrooms at Rajabhat Universities in Thailand?
3. Are there any associations between students’ perceptions of their classroom environments in mathematics and statistics classrooms and students’ attitudes toward mathematics and statistics as subjects?
4. Are there any associations between students’ perceptions of their classroom environment and students’ cognitive achievement outcomes?
5. Are there any gender differences in the students’ perceptions of students’ actual and preferred classroom environments?
RESEARCH METHODOLOGY

Population


Sample

The sample consisted of 1860 Rajabhat university students in 61 mathematics and statistics classrooms from 16 universities. The 1860 mathematics and statistics students were divided into two subgroups, the first group consisting of 860 students from 29 classes who completed the Actual and Preferred Forms of the Questionnaire on Teacher Interaction (QTI), and the second one consisting of 1000 students from 32 classes who completed the College and University Classroom Environment Inventory (CUCEI) questionnaire.

All students in a sample responded to the TOSRA scale of “Attitude Towards Subject”. And 61 teachers responded the Questionnaire on Teacher Interaction: Teacher Self Questionnaire.

Instruments used

All classroom environment instruments have two forms, namely, the Actual and Preferred forms. The actual form measures perceptions of the actual or experienced classroom environment, whereas the preferred form measures the preferred or ideal classroom environment. The preferred form is concerned with goals or the things that students desire and measure perceptions of the classroom ideally liked or preferred. Although both forms have similar wording for each item, each has different instructions for answering, such as “This teacher trusts us.” in the QTI Actual Form, while the Preferred Form changes this item to “The teacher should trust students”. “The teacher considers students’ feelings” in the CUCEI actual form is changed to “The lecturer should consider students’ feelings.” in the preferred form. Thus, the actual form requires students to respond in terms of what they really feel or think about the current classroom environment, while the preferred form requires students to think about the classroom environment which they would prefer to have. Availability of separate actual and preferred forms of the instruments enables researchers and teachers to study the differences between the actual and preferred classroom environments experienced by students as well as by teachers, and to investigate whether students achieve better results in their preferred classroom environment.

In a more recent study involving learning environment, Fraser et al. (Fraser, Gidding & McRobbie, 1992, 1995; Fraser, Fisher & McRobbie, 1996) developed a “personal form” and a “class form” to measure on an individual student’s perception in a class and to measure students’ perceptions as a whole. For example, in a personal form “I find the classwork difficult” is changed to “The classwork is difficult.” in the class form. So, the personal form of the instrument distinguishes personal perceptions from class perceptions of the classroom environment. The personal form of an instrument is sensitive for studying the learning environment within a class. Moreover, the personal form can be used to enrich data in qualitative studies of the classroom environment at different ‘grain sizes’ or degrees of analysis (Fraser, 1999).

In this study I used four instruments: the first two being the QTI and the CUCEI.

The third instrument was the attitude questionnaire, the TOSRA (the scale of “Attitude Towards Subject” only), and the fourth instrument was the cognitive achievement test, constructed by myself.

1. The first instrument was the Questionnaire on Teacher Interaction (QTI) in two forms: the Actual and Preferred Forms. Both forms had 48 items in eight scales, with six items per scale designed to measure the perceptions of mathematics and statistics students toward their instructors. All 48 items were translated into a Thai Version. This instrument was used to measure the students’ perceptions of their teachers’ behaviors in mathematics and statistics classes and to determine the association between the classroom environment and students’ cognitive achievement outcomes.

2. The second instrument was the College and University Classroom Environment Inventory (CUCEI) in two forms: the Actual and Preferred Forms similar to the QTI. The CUCEI consisted of 49 items in seven scales with seven items per scale, designed to measure the students’ perceptions of their mathematics and statistics classes and to determine associations between the learning environment and students’ cognitive achievement outcomes found in 1 above.

3. The third instrument was an attitude questionnaire, the Test of Science-Related Attitudes (TOSRA) scale. The constructs are: namely, Attitude and Efficacy which contained three scales: Attitude Towards Subject, Attitude Towards
Computer Usage, and Academic Efficacy. In this study the author used only the Attitude Towards Subject scale which contained eight items with a five-point response scale of Very often, Often, Sometimes, Seldom, and Almost Never. Both subgroups were administered the TOSRA (the scale of “Attitude Towards Subject” only) to gauge the students’ attitude toward the subjects (mathematics and statistics) after instruction. This instrument was modified from the original Test Of Science-Related Attitudes (TOSRA) version (Fraser, 1981) to reconcile it with the Thai language. The purpose of this questionnaire was to measure students’ attitudes toward mathematics and statistics, the associations between students’ learning environments; their attitudes toward the subject, and their cognitive achievement scores (final scores) in mathematics and statistics classes.

4. The fourth instrument was Questionnaire on Teacher Interaction: Teacher Self Questionnaire. This questionnaire parallels to the QTI Student Version. The purpose was used to measure teachers’ self behaviours.

DATA ANALYSIS AND THE RESULTS

The four instruments: the QTI, CUCEI, the TOSRA, and the QTI for teacher were analyzed to find the validity and reliability of the instruments. The QTI is a valid instrument followed the circumplex pattern of the Leary’s Model of Interpersonal Behaviour (Leary, 1957) both using individual student scores and class mean scores as the units of analysis (see Figures 1,2).
The reliabilities for each scale of the QTI instrument were in the acceptable ranges as shown in Table 1 using the Actual Form scores and Table 2 using the Preferred Form scores.

Table 1
The Cronbach Alpha and ANOVA Results in the Thai Version of the QTI (Actual Form)

<table>
<thead>
<tr>
<th>QTI Scales</th>
<th>No of Items</th>
<th>Alpha Reliability Coefficients</th>
<th>ANOVA Results Eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Individual Student Scores</td>
<td>Class Mean Scores</td>
</tr>
<tr>
<td>DC: Leadership</td>
<td>6</td>
<td>0.73</td>
<td>0.85</td>
</tr>
<tr>
<td>CD: Helpful/Friendly</td>
<td>6</td>
<td>0.65</td>
<td>0.70</td>
</tr>
<tr>
<td>CS: Understanding</td>
<td>6</td>
<td>0.70</td>
<td>0.82</td>
</tr>
<tr>
<td>SC: Student Responsibility/Freedom</td>
<td>6</td>
<td>0.48</td>
<td>0.71</td>
</tr>
<tr>
<td>SO: Uncertain</td>
<td>6</td>
<td>0.77</td>
<td>0.82</td>
</tr>
<tr>
<td>OS: Dissatisfied</td>
<td>6</td>
<td>0.85</td>
<td>0.81</td>
</tr>
<tr>
<td>OD: Admonishing</td>
<td>6</td>
<td>0.83</td>
<td>0.74</td>
</tr>
<tr>
<td>DO: Strict</td>
<td>6</td>
<td>0.52</td>
<td>0.72</td>
</tr>
<tr>
<td><strong>All 48 items</strong></td>
<td>48</td>
<td>0.89</td>
<td>0.87</td>
</tr>
</tbody>
</table>

**p<0.01   ***p<0.001  n = 860, 29 classes

Table 2
The Cronbach Alpha and ANOVA Results in the Thai Version of the QTI (Preferred Form)

<table>
<thead>
<tr>
<th>QTI Scales</th>
<th>No of Items</th>
<th>Alpha Reliability Coefficients</th>
<th>ANOVA Results Eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Individual Student Scores</td>
<td>Class Mean Scores</td>
</tr>
<tr>
<td>DC: Leadership</td>
<td>6</td>
<td>0.73</td>
<td>0.86</td>
</tr>
<tr>
<td>CD: Helpful/Friendly</td>
<td>6</td>
<td>0.65</td>
<td>0.82</td>
</tr>
<tr>
<td>CS: Understanding</td>
<td>6</td>
<td>0.70</td>
<td>0.82</td>
</tr>
<tr>
<td>SC: Student Responsibility/Freedom</td>
<td>6</td>
<td>0.55</td>
<td>0.60</td>
</tr>
<tr>
<td>SO: Uncertain</td>
<td>6</td>
<td>0.75</td>
<td>0.85</td>
</tr>
<tr>
<td>OS: Dissatisfied</td>
<td>6</td>
<td>0.84</td>
<td>0.89</td>
</tr>
<tr>
<td>OD: Admonishing</td>
<td>6</td>
<td>0.45</td>
<td>0.70</td>
</tr>
<tr>
<td>DO: Strict</td>
<td>6</td>
<td>0.46</td>
<td>0.75</td>
</tr>
<tr>
<td><strong>All 48 items</strong></td>
<td>48</td>
<td>0.84</td>
<td>0.88</td>
</tr>
</tbody>
</table>

**p<0.01   ***p<0.001  n = 860, 29 classes

For the CUCEI instrument, the Cronbach Alpha reliability coefficients which shown in Table 3 ranges from 0.68 to 0.85 and from 0.93 to 0.97 using individual student scores and class mean scores as the units of analyses in Actual Form.
Table 3  
*The Cronbach Alpha and ANOVA Result in the Thai Version of the CUCEI (Actual Form)*  

<table>
<thead>
<tr>
<th>CUCEI Scales</th>
<th>Alpha Reliability Coefficients</th>
<th>ANOVA Results Eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of Items</td>
<td>Individual Student Scores</td>
</tr>
<tr>
<td>Personalisation</td>
<td>7</td>
<td>0.78</td>
</tr>
<tr>
<td>Involvement</td>
<td>7</td>
<td>0.68</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>7</td>
<td>0.85</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>7</td>
<td>0.77</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>7</td>
<td>0.73</td>
</tr>
<tr>
<td>Innovation</td>
<td>7</td>
<td>0.77</td>
</tr>
<tr>
<td>Individualisation</td>
<td>7</td>
<td>0.74</td>
</tr>
<tr>
<td><strong>All 49 items</strong></td>
<td>49</td>
<td><strong>0.95</strong></td>
</tr>
</tbody>
</table>

***p<0.001, n = 1000, 32 classes

For the CUCEI instrument, the Cronbach Alpha reliability coefficients which shown in Table 4 ranges from 0.46 to 0.70 and from 0.82 to 0.91 using individual student scores and class mean scores as the units of analyses in Preferred Form.

Table 4  
*The Cronbach Alpha and ANOVA Results in the Thai Version of the CUCEI (Preferred Form)*  

<table>
<thead>
<tr>
<th>CUCEI Scales</th>
<th>Alpha Reliability Coefficients</th>
<th>ANOVA Results Eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No of Item</td>
<td>Individual Student Scores</td>
</tr>
<tr>
<td>Personalisation</td>
<td>7</td>
<td>0.67</td>
</tr>
<tr>
<td>Involvement</td>
<td>7</td>
<td>0.46</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>7</td>
<td>0.70</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>7</td>
<td>0.70</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>7</td>
<td>0.69</td>
</tr>
<tr>
<td>Innovation</td>
<td>7</td>
<td>0.54</td>
</tr>
<tr>
<td>Individualisation</td>
<td>7</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>All 49 items</strong></td>
<td>49</td>
<td><strong>0.92</strong></td>
</tr>
</tbody>
</table>

***p<0.001, n = 1000, 32 classes

The reliabilities of the TOSRA scale (the scale of “Attitude Towards Subject”) which both using with QTI and CUCEI are in the acceptable values shown in Table 5.

Table 5  
*Internal Consistency Reliability Coefficients (Cronbach Alpha) for Individual Student Scores and Class Mean Scores*  

<table>
<thead>
<tr>
<th>Scale</th>
<th>Unit of Analysis</th>
<th>Number of Items</th>
<th>Alpha Reliability Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>QTI subgroup</td>
</tr>
<tr>
<td>Attitude Towards</td>
<td>Individual student score</td>
<td>8</td>
<td>0.88</td>
</tr>
<tr>
<td>Subject</td>
<td>Class Mean Scores</td>
<td>8</td>
<td>0.97</td>
</tr>
</tbody>
</table>
ANSWERS TO THE RESEARCH QUESTIONS

Based on analysis of both the quantitative and qualitative data in previous section, all major findings and research questions are described in the sections following.

Research Question 1
Is the modified QTI a valid and reliable instrument to assess students’ perceptions of their teachers’ behaviours in mathematics and statistics classrooms at Rajabhat Universities in Thailand?

The data analyses confirmed the QTI was a valid instrument according to Leary’s circumplex model (Fisher & Poh, 1997) using the individual student scores as the unit of analysis. The Leadership scale highly correlated with the Helpful/Friendly scale, which was the adjacent scale (to the Leadership scale) on the circumplex model.

The circumplex pattern of this instrument was validated by both using the individual student scores and the class mean scores as the unit of analyses. Consequently, the Thai version of the QTI was found to be a valid instrument for use to measure students’ perceptions of learning environments in mathematics and statistics classrooms at Rajabhat Universities in Thailand.

The Cronbach Alpha reliability coefficients were computed to determine the internal consistency reliability of the QTI, with both the individual student and the class mean as the units of analyses. Using individual student and class mean as the units of analysis, the Cronbach Alpha reliability coefficients of the eight scales of the QTI both were in acceptable ranges (see Tables 1, 2). Therefore, the Cronbach Alpha reliability coefficients of the QTI (Thai Version) in this study were acceptable, so the QTI can be use to measure students’ perceptions of their teachers’ behaviours in Thai mathematics and statistics classroom with confidence. In addition, from ANOVA results the seven scales of the QTI in Thai version could differentiate students’ perceptions of their teachers’ behaviours between classrooms.

The results of this study confirmed the validity and reliability of Thai version of the QTI and thus have answered the Research Question 1, that is, the QTI is a valid and reliable instrument for use in mathematics and statistics classes at Rajabhat Universities in Thailand.

Research Question 2
Is the modified CUCEI a valid and reliable instrument to assess the students’ perceptions of their classroom environments in mathematics and statistics classrooms at the Rajabhat Universities in Thailand?

The ANOVA results indicated that all scales of the CUCEI could differentiate students’ perceptions of their classroom environment significantly between the mathematics and statistics classrooms. Consequently, the Thai version of the CUCEI is a valid instrument which has a discriminant validity, so it was appropriate instrument for use to measure students’ perceptions of their learning environments in mathematics and statistics classrooms.

Using the student Actual Form scores for data analysis, the Cronbach Alpha reliability coefficients of the CUCEI were in acceptable ranges, both using the individual student scores and the class mean scores as the units of analysis (see Tables 3 and 4). These findings demonstrated that the CUCEI is a reliable instrument. In answer to the Research Question 2, the Thai Version of the CUCEI could be utilize to gauge students’ perceptions of their classroom environment in mathematics and statistics classrooms at Rajabhat Universities in Thailand with confidence.

Research Question 3
Are there any associations between the students’ perceptions of their classroom environment in mathematics and statistics classrooms and students’ attitudes toward mathematics and statistics as the subjects?

The three instruments: the QTI, the CUCEI and the TOSRA (the scale of “Attitude Towards Subject” only) were used to examine the associations between students’ perceptions of classroom environments and their attitudes toward mathematics and statistics as the subjects. The statistics used to find the associations were the simple correlation, multiple correlation and the standardized regression coefficients using both individual student scores and class mean scores as the units of analyses.

The results of the study indicated that the four scales of the QTI – Leadership, Helpful/Friendly, Understanding, and Student Responsibility/Freedom behaviours – correlated significantly with the students’ attitude towards subject when both using the individual student scores and class mean scores as the unit of analyses. These findings indicated that the teachers and instructors who demonstrated above behaviours positively influenced students’ attitude toward the subjects. The 14% and 44% of variances in students’ attitude toward subject could be attribute to their perceptions of their teachers’ behaviours both using individual student scores and class mean scores as the unit of analyses respectively. These findings indicated that, on the whole, teachers’ behaviours influenced students’ attitude toward mathematics and statistics.
The simple correlations between the CUCEI scales and the students' attitudes toward subject scale were positively correlated with the seven scales: Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualization when using the individual student scores as the unit of analysis. Consequently, the higher degree of Personalization, Involvement, Satisfaction, Task Orientation, Innovation, and Individualization the students perceived their classroom environment the better were their attitude towards subject. However, the CUCEI scales of Satisfaction correlated with the students’ attitude toward subject when using the class mean scores as the unit of analysis.

Using individual student scores as the unit of analysis, the multiple correlation (R=0.36) between the CUCEI scales and students’ attitude toward subject was positively significant. The R^2 were 0.13 and 0.34 for individual and class mean as the unit of analyses indicating that the 13% and 34% of the variances in students’ attitude toward subject could be attributed to their perceptions of their classroom learning environments.

**Research Question 4**

*Are there any associations between the students’ perceptions of their classroom environments in mathematics and statistics classrooms and students’ cognitive achievement outcomes?*

To this question the simple correlations between the QTI scales and students’ cognitive achievement scores revealed that there were significant in the eight scales of Leadership, Helpful/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behaviours using the individual student as the units of analysis, but only three scales of the QTI, Uncertain, Dissatisfied, and Strict behaviours, were negatively correlated and significant when using individual student as the units of analysis. The strong evidences of the negative correlation between the Uncertain, Dissatisfied and Strict scales with the students’ cognitive achievement scores indicated that the teachers who had been more rated in the three behaviours: Uncertain, Dissatisfied, and Strict scales the lower were their achievement scores, in contrast, the teachers who had been more rated in the scales of Leadership and Understanding the better were their achievement scores in the final examination.

The regression analysis using the individual student scores as the unit of analysis indicted that, as a whole, all scales of the QTI affected the students’ cognitive achievement scores. The teachers who achieved more in the scales of Helping/Friendly, Understanding, Admonishing, and Strict behaviours appeared to influence students’ cognitive achievement scores. The portion of variance in students’ cognitive achievement outcomes that can be attributed to their perceptions of teacher behaviour (QTI scale) were respectively 14% and 57%, using the individual student scores and class mean scores as the unit of analyses as indicated that teacher’s behaviour is a factor to enhance students’ cognitive achievement outcomes. These findings of the study have answered the Research Question 4 for using the QTI instrument. That is, there are associations between classroom environment and students’ cognitive achievement outcomes.

To answer Research Question 4 for using the CUCEI instrument, the results from data analysis in Table 3 were examined. The simple correlations between the CUCEI scales and the students’ cognitive achievement scores using the individual student scores as the unit of analysis were positively significantly correlated with the scales of Personalisation, Involvement, Satisfaction, and Individualisation. These results indicated that the teachers who possessed behaviours related to these four scales may have contributed to higher students’ cognitive achievement scores.

As for using the class means as the units of analysis, none of the scales of the CUCEI was positively and significantly correlated with the students’ cognitive achievement scores. But two scales of Student Cohesiveness and Task Orientation were negatively correlated with students’ cognitive achievement scores.

The multiple correlation analysis showed that, as a whole, the CUCEI scales were significantly correlated with students' cognitive achievement scores and the percentage of variance in students' cognitive achievement scores were accounted for by the CUCEI scales in 8% and 67% for individual student and class mean as the unit of analyses respectively.

These findings of the study have answered Research Question 4 for using the CUCEI instrument. That is, the Personalization, Involvement, Satisfaction, and Individualisation scales were positively correlated with the students’ cognitive achievement scores and the scales of Student Cohesiveness, Task Orientation scales were negatively correlated with attitude towards subject when using the individual student scores as the unit of analysis.
**Research Question 5**

*Are there any gender differences in the students’ perceptions of students’ actual and preferred classroom environments?*

Answering Research Question 5, the t-test for independent samples was used. Using Actual Form scores of the QTI for data analysis, the mean scores of male and female students were significant difference in the scales of Uncertain, Dissatisfied and Admonishing. For using Preferred form scores, there were significant gender differences in the scales of Student Responsibility/Freedom and Uncertain behaviours. The findings indicated that the male and female students interpreted their teachers’ behaviours differently in the scale of Student Responsibility/Freedom, Uncertain, Dissatisfied, and Admonishing.

The scale means of the QTI for both male and female students in the Preferred Form scores were higher than the scale means of the Actual Form in the scales of Leadership, Helpful/Friendly, and Understanding. Student Responsibility/Freedom, Dissatisfied, and Admonishing. In contrast, the means of the Preferred Form of both the male and female students were lower than the means of the Actual Form scores in the scales of Uncertain, and Strict behaviours.

These findings indicated that the male and female students preferred the teachers to exert more Leadership, Helpful/Friendly, Understanding and Student Responsibility/Freedom, Dissatisfied and Admonishing behaviours than they actually did.

To measure students’ perceptions of classroom environment using the CUCEI, the Actual and Preferred Form scores were examined. Comparing the Actual and Preferred Form score means between male and female students indicated that the scales of Involvement, Student Cohesiveness, and Individualisation in the Actual Form displayed significant gender differences, but not in the other four scales.

And when the Preferred Form scores were used, the male and female students perceived their classroom environment differently in scales of Involvement, Task Orientation, Innovation, and Individualisation. Both male and female students perceived their learning environment in Preferred Form scores more than the Actual Form scores for every scales of the CUCEI.

These findings answered Research Question 5 about gender differences in students’ perceptions of classroom environment. That is, there were gender differences in the scales of Student Responsibility/Freedom, Uncertain, Dissatisfied, and Admonishing of the QTI scales and the Involvement, Student Cohesiveness, Individualisation of the CUCEI scales when using individual student scores as the unit of analysis in Actual Form.

**CONCLUSION AND DISCUSSION**

Two instruments, the QTI and the CUCEI are valid and reliable for use to assess Thai students’ perceptions of their learning environment in mathematics and statistics classrooms at the Rajabhat Universities in Thailand. The Cronbach Alpha reliability coefficients of the QTI’ scales ranged from 0.48 to 0.85 and from 0.70 to 0.85 using the individual student scores and the class mean scores as the units of analyses in Actual Form scores. But in using the Preferred Form scores, the Cronbach Alpha coefficients ranged from 0.45 to 0.84 and from 0.60 to 0.89 using individual student scores and class mean scores as the units of analyses. The Cronbach Alpha reliability coefficients of the CUCEI scales ranged from 0.68 to 0.85 and from 0.93 to 0.97 using individual student scores and class mean scores as the units of analyses in Actual Form scores. But using the Preferred Form scores, the Cronbach Alpha reliability coefficients ranged from 0.50 to 0.70 and 0.82 to 0.91 using individual student scores and class mean scores as the units of analyses.

Associations between students’ perceptions of their classroom environment using the QTI and students’ attitudes toward subjects were positively related in scales of Leadership, Helpful/Friendly, Understanding and Student Responsibility/Freedom and 14% of variances in students’ attitude toward subject could be attributed to their perceptions of their teachers’ behaviours.

Using the CUCEI, the scales of Personalization, Involvement, Satisfaction, Student Cohesiveness, Task Orientation, Innovation, and Individualization were positively and significantly related with students’ attitudes toward subjects. The 13% of variances in students’ attitudes toward subject was explained by classroom learning environment assessed by the CUCEI scales.

Comparison of students’ perceptions of their teachers’ behaviours and classroom learning environments between male and female students indicated that the male and female students perceived differently in scales of Uncertain, Dissatisfied, and Admonishing measured by the QTI, but when measured by CUCEI, the male and female students perceived differently in scales of Involvement, Student Cohesiveness, and Individualisation; both the QTI and CUCEI used in Actual Form scores.
Comparison of students’ perceptions of their teachers’ behaviours with the teachers perceived themselves indicated that the teachers responded more than students did in scales of Leadership, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, and Admonishing, but the students perceived more than teachers did in scales of Helpful/Friendly, and Strict.

REFERENCES


ABSTRACT

The purposes of this study were to examine what classroom learning environment profiles could be discerned in high school biology classrooms. Data on students’ perceptions of their learning environment were collected by the What Is Happening In this Classroom (WIHIC) questionnaire. The WIHIC maps several important dimensions of the science classroom environment: investigation, cooperation, teacher support, student cohesiveness, involvement, task orientation, understanding, and equity. To our knowledge this is the first attempt to construct a typology based on data of the questionnaire. Such profiles may help in teacher and school professional development, as they provide instant pictures that are helpful in reflective processes. Data were gathered from 1474 high school students in four inner city schools in Bursa, Turkey. A total of 11 biology teachers participated in the study with 52 of their classes. Using data collected with the actual form of WIHIC, cluster analyses were conducted to derive a typology of learning environments. Six distinct typologies were found: ‘the self-directed learning classroom’, ‘the task-based cooperative learning classroom’, ‘the mainstream classroom’, ‘the subject-oriented individualized classroom’, ‘the low-effective learning classroom’ and ‘the high-effective learning classroom’. The most common profile was the mainstream classroom, followed by the task-based cooperative learning classroom. The profiles explained high amounts of variance in student outcomes and the WIHIC scales.

RATIONALE

In order to stimulate teachers’ professional development with respect to creating a science learning environment in directions that promote positive student outcomes and meaningful learning, instruments devised to measure students’ (and teachers’) perceptions can be very helpful. If teachers can compare their own views with those of their students or their own preferences, differences between each of these views can provide interesting clues for change in behaviour (den Brok, Bergen, & Brekelmans, 2006; Fisher, Fraser, & Cresswell, 1995; Fisher & Rickards, 2000). Teacher reflection on their own and their students’ perceptions of teaching and the learning environment may be further enhanced if information containing these perceptions is presented in various ways (Wubbels, 1992). Images or profiles are one of these alternative ways of presenting such information, next to written information on item, scale or (higher order) dimension scores. Images and profiles are powerful tools for reflection because they can be used to conceptualise complex and interrelated information, because they can summarise information into (smaller) chunks that are easier to comprehend, and because they can stimulate associations and links within the teachers’ own knowledge if they are accompanied with powerful labels (e.g. Copeland, Birmingham, de la Cruz, & Lewin, 1993; Weber & Mitchell, 1996; Wubbels, 1992).

The present study aims at creating a typology of science classroom (in our case biology classrooms) learning environments based on students’ perceptions. The creation and empirical investigation of typologies is not a common practice in science learning environments research. To our knowledge there is only one typology to describe learning environments, and it was produced by Moos’ (1979) Classroom Environment Scale (Fraser, 1986). It features five clusters which describe the following learning-environment orientations: control, innovation, affiliation, task completion and competition. There are more typologies available of teaching styles (Bennett, 1976; Good, 1979; Schultz, 1982; Ramsay and Ransley, 1986). Most of these typologies distinguish between directive and non-directive approaches to teaching, in which non-directive teachers emphasise support, innovative instructional procedures and flexible rules and directive teachers emphasise control and seek to develop competitive, task-oriented classes. Research on teacher-student interpersonal relationships, which traditionally has been linked strongly to the domain of (science) learning environments research, has produced an eight-fold typology of interpersonal teaching styles consisting of Authoritative, Tolerant-Authoritative, Directive, Tolerant, Uncertain-Tolerant, Uncertain-Aggressive, Repressive and Drudging teachers (Brekelmans,
Levy, & Rodriguez, 1993). This typology has been replicated in different countries, such as the Netherlands and USA (Brekelmans, et al., 1993), Australia (Rickards, den Brok, & Fisher, 2005) and Turkey (Telli, 2006). Moreover, the typology has shown strong connection to student outcomes, with some styles – e.g. the Authoritative, Tolerant-Authoritative and Directive styles - producing higher achieving and more motivated students (Brekelmans, et al., 1993; Wubbels & Levy, 1993; Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006).

The instrument of the present study was developed by Fraser, Fisher and McRobbie (1996), and is known as the What Is Happening In this Class? (WIHIC). There are several reasons for focusing on this particular instrument. First, the WIHIC combines relevant dimensions from learning environment instruments, such as investigation and relationships between teacher and students (Dorman, 2003). Secondly, the WIHIC is one of the most widely-used instruments in the domain of learning environments research and has been validated in a number of countries (e.g. Aldridge, Laugksch, & Fraser, 2004). Thirdly, the instrument is capable of reliably measuring students’ perceptions of important elements of their learning environment and has demonstrated predictive validity on both cognitive and affective student outcomes (e.g. Fraser, 2002). Fourth, due to the limited number of items (56 in total) and scales (7 in total), the instrument is easy to use in the classroom and only takes small amounts of time from participating students and teachers.

Studies on learning environments have been virtually absent in the Turkish context, in part due to the lack of suitable (and culturally relevant) instruments (Tuzun, 2006; Acikgoz, Ozkal & Kilic, 2003). A study on typologies of Turkish science learning environments not only would be interesting from this perspective, but also for other reasons. The promotion of favourable attitudes towards science is among the top objectives of science education in many countries (Fraser, 1981; Scott, den Brok & Fisher, 2004) and Turkey is no exception in this respect. From this perspective, there is a clear need for further and deeper insight into the factors that may cause low achievement and to find ways to increase both attitudes towards science. Teacher reflection on their teaching and the creation of a favourable environment may be helpful in this respect. Studying on typologies in science classrooms can provide empirical support for science teacher education and their professional development in Turkey. Although Turkey has faced several nation-wide reforms in teacher education and teacher training (Cakiroglu, & Cakiroglu, 2003; Grossman, Onkol, & Sands, 2007), these reforms largely addressed teacher behaviour and methods or the curriculum directly, rather than being aimed at teacher reflection on their behaviour. Teachers can be provided with personal feedback on the scale, item and dimension scales. As such feedback, they can compare their own perceptions with their ideals or the perceptions of their students, and they can compare their own perceptions or those of their students with each of the different types to see with which typologies they fit best. This feedback system can be valuable means for the teachers’ professional development. It helps the teachers to improve their practice in conducting science teaching and assists them to enhance their classroom environment.

THEORETICAL FRAMEWORK

The ‘What Is Happening In this Classroom’ (WIHIC) questionnaire

Developed by Fraser, Fisher, and McRobbie (1996), the WIHIC measures high school students' perceptions of their classroom environment. The WIHIC measures a wide range of dimensions that are important to the current situation in classrooms. The WIHIC includes relevant dimensions from past questionnaires and combines these with dimensions that measure particular aspects of constructivism and other relevant factors operating in contemporary classrooms. It was designed to bring parsimony in the field of learning environments research (Dorman, 2003). A description of each scale in the WIHIC is presented in Table 1 below. As can be seen, the WIHIC covers key dimensions considered important in learning environments.

Studies using the WIHIC have investigated a host of topics related to science learning environments. Among reported findings are positive associations between most WIHIC scales and cognitive and affective student outcomes, (Dorman, Fisher, & Waldrip, 2006), lower student perceptions for the actual learning environment (in terms of the seven scales) than for the preferred learning environment (Wahyudi & Treagust, 2004) and differences between countries (Aldridge, et al., 2004). Also, differences in WIHIC scale scores have been reported according to several student, teacher and class background characteristics (den Brok, et al., 2006). Recently, some WIHIC related studies have shown that school-based interventions can enhance (elements of) the learning environment and students’ perceptions of it (Ogbuehi, & Fraser, 2007). Only a few prior studies with the WIHIC have been conducted in Turkey, most of which involved work by (one or more of) the authors (e.g. Telli & Cakiroglu, 2002; Telli, Cakiroglu, & den Brok, 2006; Cakiroglu, Tekkaya, & Rakici , 2007).
Table 1

Scale Descriptions for Each Scale in the WIHIC Questionnaire

<table>
<thead>
<tr>
<th>WIHIC scale</th>
<th>The extent to which...</th>
<th>Moos (1979) dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>...students are friendly and supportive of each other.</td>
<td>Relationship</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>...the teacher helps, be friends and is interested in students.</td>
<td>Relationship</td>
</tr>
<tr>
<td>Involvement</td>
<td>...students have attentive interest, participate in class and are involved with other students in assessing the viability of new ideas.</td>
<td>Relationship</td>
</tr>
<tr>
<td>Investigation</td>
<td>…there is emphasis on the skills of inquiry and their use in problem-solving and investigation.</td>
<td>Personal growth</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>...it is important to complete planned activities and stay on the subject matter.</td>
<td>Personal growth</td>
</tr>
<tr>
<td>Cooperation</td>
<td>...students cooperate with each other during activities.</td>
<td>Personal growth</td>
</tr>
<tr>
<td>Equity</td>
<td>...the teacher treats students equally, including distributing praise, question distribution and opportunities to be included in discussions.</td>
<td>System maintenance and change</td>
</tr>
</tbody>
</table>

Creating typologies of learning environments

The most elaborated (and also most verified) attempt to create a typology of learning environments was the study by Brekelmans et al. (2003). This study included a number of steps to arrive at a typology of teacher-student interpersonal profiles. Using data gathered with the QTI (Questionnaire on Teacher Interaction), researchers conducted cluster analyses (Everitt, 1980; Wishart, 1978) to derive a typology of interpersonal teaching styles (e.g., Brekelmans, et al., 1993). The typology found was further validated by observations in classrooms showing qualitative differences between each of the eight types. A separate hand-sort of ‘teaching profiles’ (e.g., visual representations of scale scores on the QTI) conducted by the researchers involved (e.g. Brekelmans et al., 1993) also resulted in a set of types similar to the one found by statistical analyses. The eight interpersonal types were finally linked to student outcomes to test whether they could explain significant amounts of variance (Brekelmans, et al., 1993).

However, while several studies have been focussed on interpersonal profiles, typologies have not yet been created for other learning environment instruments such as the WIHIC. For that reason, the purpose of this study was to examine the typologies discerned in high school biology classrooms. So, specifically, the current study aimed at addressing the following research question: Which typologies can be discerned based on class means of students’ perceptions in biology learning environments in Turkey?

METHOD

Sample

The participants of this study were 1474 students (Grades 9 to 11) from 52 classes in four inner city schools, in Bursa, Turkey. In terms of student gender distribution, 829 (56.5 %) girls and 606 (41.3 %) boys were sampled, 33 students (2.2 %) made no indication of gender. Grade level distribution was as follows: 54.8% of the students were located in grade nine, 25.5% in grade ten and 19.8% in grade eleven. A total number of 11 biology teachers (3 male and 8 female) participated in the study. Class size in the schools varied from 19 to 41 students, with an average of 28.3 students. In terms of class composition variables, the sample was diverse. The average percentage of girls and boys varied between classes, but no class consisted uniquely of girls or boys.

Instrumentation

To assess students’ perceptions of their learning environment, the WIHIC was administered to all students of participating classes and schools. As it has been reported, the WIHIC measures the following seven dimensions
of the classroom environment: Student Cohesiveness, Involvement, Investigation, Task Orientation, Cooperation and Equity. It contains 56 items that are answered on a five point Likert type Scale.

Several analyses were done to investigate its construct and predictive validity. First, reliability (alpha) was computed and ranged between .78 (Student Cohesiveness) and .87 (Equity) at the student level and between .85 (Investigation) and .94 (Teacher Support and Equity) at the class level. Percentages of variance at the class level were rather low, ranging from 8 (Investigation) to 17 (Teacher Support). Finally, correlations between the WIHIC scales were computed, in order to see whether they referred to distinctively different aspects of the learning environment. The scales seemed to measure distinct aspects, but also show some overlap (as correlations ranged between .25 and .40 in most cases). This was particularly true for Task Orientation and Investigation (.53), Involvement and Teacher Support (.51), and Cooperation and Cohesiveness (.50).

For students’ affective outcomes, they were asked to respond to a 5-item Likert-type scale regarding their attitude toward their biology course (i.e. enjoyment, usefulness, competence and time investment). In addition, students’ report card grades which provided an indication for students’ success in biology course were used as outcome measure.

Analysis

To discern the typology of learning environments, a cluster analysis was conducted on actual class level of student data with SPSS. Following suggestions by Brekelmans (1989) squared Euclidian distances were used to distinguish between groups and the complete linkage and Ward methods to establish cluster profiles. Mean scale scores of clusters and means of clusters on outcome variables were computed. The clusters were interpreted and given a label based on a graphical profile. An analysis of variance (ANOVA) on the seven dimensions scores with the constructed typology as the explanatory variable was used to check if sufficient amounts of variance could be explained in a scale score by the cluster division. Also, cluster differences in student outcomes were established by means of a variance analysis.

RESULTS

Using data gathered with the WIHIC, a series of cluster analyses were conducted testing a range of solutions between two and eight profiles. In solutions with seven or eight clusters, some clusters were very small in size while not being very different in terms of average scale scores from other clusters. In solutions with four or less clusters, the solutions seemed to explain small amounts of variance in some WIHIC scales. However, a solution containing six profiles explained significant amounts of variance in the scales and profiles seemed optimally different. Moreover, the six profile solution also emerged as most suitable in cluster analyses using other clustering methods. Thus, further analyses were conducted based on these six clusters.

The clusters can be described (and interpreted) as follows, The first cluster was named self-directed learning classroom (SDLC) as its means were low for teacher support, high for student cohesiveness and cooperation, and relatively low for the other scales. The second cluster was labelled task-based cooperative learning classroom (TBCLC) and is characterized by high student cohesiveness and cooperation, relatively high teacher support and high investigation and task orientation. The third cluster had no typical profile and is characterized by medium scores on almost all WIHIC scales, and was therefore labelled as the mainstream classroom (AC). The fourth cluster was characterized by low scores on student cohesiveness and cooperation, high scores on task orientation and relatively high scores on investigation and was named subject oriented individualized classroom (SOIC). The fourth cluster was characterized by low scores on student cohesiveness and cooperation, high scores on task orientation and relatively high scores on investigation and was named subject oriented individualized classroom (SOIC). The fourth cluster was characterized by low scores on student cohesiveness and cooperation, high scores on task orientation and relatively high scores on investigation and was named subject oriented individualized classroom (SOIC). The last two clusters, five and six, were named respectively as low effective learning classroom (LELC) and high effective learning classroom (HELC). The former was typical because of its low scores on involvement, investigation, task orientation, and medium to low scores on the other scales and the latter had highest scores (of all clusters) on all scales (and the second highest score on investigation). The clusters were thus given a label based on a graphical profile (Figure 1), that resulted from cluster scale means (see Table 2).
### Table 2: WIHIC Scale Means for Each of the Six Clusters

<table>
<thead>
<tr>
<th>Profile</th>
<th>Student cohesiveness</th>
<th>Teacher support</th>
<th>Investigation</th>
<th>Involvement</th>
<th>Task orientation</th>
<th>Cooperation</th>
<th>Equity</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDLC</td>
<td>.70</td>
<td>.34</td>
<td>.53</td>
<td>.53</td>
<td>.70</td>
<td>.60</td>
<td>.59</td>
</tr>
<tr>
<td>TBCLC</td>
<td>.71</td>
<td>.52</td>
<td>.62</td>
<td>.61</td>
<td>.78</td>
<td>.63</td>
<td>.71</td>
</tr>
<tr>
<td>AC</td>
<td>.66</td>
<td>.47</td>
<td>.54</td>
<td>.59</td>
<td>.73</td>
<td>.60</td>
<td>.72</td>
</tr>
<tr>
<td>SOIC</td>
<td>.59</td>
<td>.43</td>
<td>.58</td>
<td>.54</td>
<td>.78</td>
<td>.54</td>
<td>.69</td>
</tr>
<tr>
<td>LELC</td>
<td>.61</td>
<td>.42</td>
<td>.50</td>
<td>.56</td>
<td>.65</td>
<td>.55</td>
<td>.62</td>
</tr>
<tr>
<td>HELC</td>
<td>.73</td>
<td>.59</td>
<td>.61</td>
<td>.68</td>
<td>.81</td>
<td>.69</td>
<td>.82</td>
</tr>
</tbody>
</table>

Chi-squared  
SDLC 14.07  
TBCLC 31.82  
AC 20.23  
SOIC 9.45  
LELC 19.08  
HELC 15.48

p-value  
SDLC .00  
TBCLC .00  
AC .00  
SOIC .00  
LELC .00  
HELC .00

Percentage explained  
SDLC .61  
TBCLC .78  
AC .51  
SOIC .69  
LELC .68  
HELC .63

Note: SC=Student Cohesiveness, TS= Teacher Support, I= Investigation, IV= Involvement, TO= Task Orientation, C= Cooperation, E= Equity, SDLC= self-directed learning classroom, TBCLC=task-based cooperative learning classroom AC= Mainstream classroom SOIC= subject oriented individualized classroom, LELC= low effective learning classroom, HELC= high effective learning classroom.

**Figure 1.** Six distinct typologies of the biology learning environment.

According to Table 3, high effective learning classroom (HELC) have the highest mean scores on student affective outcomes, followed by subject oriented individualized classroom (SOIC). The lowest attitude mean scores were obtained in self-directed learning classroom (SDLC) and low effective learning classroom (LELC). Analysis of variance showed that there were significant differences among the attitudes scores of the six distinct clusters. The same result was not observed for students’ report card grades.
### Table 3

Mean Attitude per Cluster, Analysis of Variance, Percentage Explained by Cluster

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Enjoyment</th>
<th>Usefulness</th>
<th>Competent</th>
<th>Interest</th>
<th>Time investment</th>
<th>Report card</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDLC</td>
<td>1.88</td>
<td>2.51</td>
<td>2.06</td>
<td>1.99</td>
<td>1.71</td>
<td>4.11</td>
</tr>
<tr>
<td>TBCLC</td>
<td>2.48</td>
<td>3.03</td>
<td>2.28</td>
<td>2.59</td>
<td>2.10</td>
<td>3.77</td>
</tr>
<tr>
<td>AC</td>
<td>2.31</td>
<td>2.84</td>
<td>2.09</td>
<td>2.34</td>
<td>1.97</td>
<td>4.04</td>
</tr>
<tr>
<td>SOIC</td>
<td>2.78</td>
<td>3.17</td>
<td>2.39</td>
<td>2.70</td>
<td>2.33</td>
<td>3.32</td>
</tr>
<tr>
<td>LELC</td>
<td>1.99</td>
<td>2.41</td>
<td>2.10</td>
<td>1.98</td>
<td>1.86</td>
<td>3.94</td>
</tr>
<tr>
<td>HELC</td>
<td>2.38</td>
<td>2.85</td>
<td>2.22</td>
<td>2.41</td>
<td>2.04</td>
<td>4.20</td>
</tr>
<tr>
<td>F-value</td>
<td>7.56</td>
<td>7.00</td>
<td>5.80</td>
<td>7.63</td>
<td>6.78</td>
<td>.89</td>
</tr>
<tr>
<td>Sig.</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.00</td>
<td>.49</td>
</tr>
<tr>
<td>% explained</td>
<td>45</td>
<td>43</td>
<td>39</td>
<td>45</td>
<td>42</td>
<td>9</td>
</tr>
</tbody>
</table>

### DISCUSSION

The present study investigated typologies discerned in Turkish school biology classrooms by using the WIHIC. Findings demonstrated the presence of six distinct typologies, namely ‘the self-directed learning classroom (SDLC)’, ‘the task-based cooperative learning classroom (TBCLC)’, ‘the mainstream classroom (AC)’, ‘the subject-oriented individualized classroom (SOIC)’, ‘the low-effective learning classroom (LELC)’ and ‘the high-effective learning classroom (HELC)’. The mainstream classroom was found to be the most common profile in the biology classes. The second most common profile was found to be task-based cooperative learning classroom.

There are a number of limitations of the present study which might have implication for further research. First, the study was limited by its reliance on self-reported data. Subsequent research is needed to verify the consistency and accuracy of the present findings through use of multiple methods and measures. Conducting interviews and videotaped lessons in future research might provide a broader and more comprehensive description of a typology of the science learning environment in general, and the biology learning environment in particular. Second, we conducted this investigation in 52 classes in four inner city schools located in a big city in Turkey. Therefore, results cannot be easily generalised to the country’s population as a whole. The generalisation of the results from this study, hence, should be viewed with caution.

### REFERENCES


SUBJECT OR STYLE? DIFFERENCES IN TEACHER-STUDENT INTERPERSONAL BEHAVIOUR BETWEEN SCIENCE TEACHERS AND TEACHERS OF OTHER (SCHOOL) SUBJECTS

Perry den Brok and Ruurd Taconis  
Eindhoven University of Technology,  
The Netherlands  
Darrell Fisher  
Curtin University of Technology  
Australia

ABSTRACT

During the last 25 years a large number of studies in science education have been conducted on students’ and teachers’ perceptions of teacher-student interpersonal behaviour. Studies comparing these perceptions between different school subjects have been rare and subject taught was often not a variable of central concern. The present study compares perceptions of students (and teachers) of the interpersonal behaviour of teachers between science teachers and teachers of other school subjects. Perceptions were studied with the Questionnaire on Teacher Interaction (QTI) which maps interpersonal teacher behaviour along two dimensions: Influence (degree of teacher control) and Proximity (degree of cooperation between teacher and students). An already existing QTI database of teachers in Dutch secondary education was reanalyzed and contained data of 44,353 students, located in 1,820 classes from 605 teachers in 201 secondary education schools from all across the Netherlands. Teachers of these students taught different school subjects, but 8,503 students (19.2 percent) reported perceptions on science teachers. Multilevel analyses of variance indicated that science teachers were perceived as less dominant and less cooperative. These patterns were also found in teachers’ self-perceptions, though less pronounced. In terms of interpersonal profiles it was found that science teachers were relatively less often perceived as Directive, Authoritative or Tolerant/Authoritative compared to teachers of other subjects, but relatively more often as Tolerant and Uncertain/Tolerant. In a similar fashion, science teachers perceived themselves relatively less often as Authoritative or Tolerant/Authoritative, but relatively more often as Tolerant, Uncertain/Tolerant and to some degree Uncertain/Aggressive.

RATIONALE

During the last 25 years within the field of Learning Environments Research a large number of studies have been conducted on students’ and teachers’ perceptions of teacher-student interpersonal behaviour. These studies have investigated links to student outcomes, links to perceptions of other teacher behaviours, interpersonal profiles, teacher non-verbal behaviours, development of interpersonal behaviour during the teaching career, the effects of student and teacher background characteristics – such as gender, ethnicity, age, experience – class and school characteristics – such as class or school size, ethnic and gender distribution, school type – assessment and educational innovations, among many other topics (e.g. den Brok, & Levy, 2005; Wubbels, & Brekelmans, 2005; Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006).

Most of these studies have been conducted within secondary education and within the science subjects (math, chemistry, physics, biology), although other subjects have been studied as well (Wubbels, & Brekelmans, 1998; den Brok, Brekelmans, & Wubbels, 2004). However, studies comparing perceptions of teacher interpersonal behaviour between different school subjects have been rare and in cases where subject taught was investigated, it was not the variable of central concern (Levy, den Brok, Wubbels, & Brekelmans, 2003).

The present study compares perceptions of students (and teachers) of the interpersonal behaviour of teachers between science teachers and teachers of other school subjects. Such a comparison may be interesting and relevant for a number of reasons. First, in many countries few students decide to pursue a career in science or mathematics and only a small number of students enrol in science classes (Dekkers, & De Laeter, 2001). Undoubtedly the teacher and his or her pedagogical style play an important role in this. Secondly, many students may have prototypical images (or prejudices) of science, scientists and their science teachers that may affect the way in which they perceive and interact with their teachers and vice versa (Aikenhead, 2003; Gaskell, 1992; Knain, 2001). Thirdly, science teachers themselves may have specific beliefs regarding their subject. For example, there is some evidence that some teachers regard the knowledge of their subject as more absolute and of higher status compared with other subjects, which in turn may result in less student-directed and more subject-directed teaching styles (Aikenhead, 2003). This in turn may lead to different perceptions of interpersonal behaviour by teachers themselves and by their students.
THEORETICAL FRAMEWORK: TEACHER-STUDENT INTERPERSONAL BEHAVIOUR

The conceptualization of teacher-student interpersonal behaviour as used in the present study has been described by Wubbels and Levy (1993) more completely and we only summarize it here. To describe rather stable patterns of interpersonal behaviour students’ (and teachers’) perceptions of their teachers’ interpersonal behaviour are studied with the Leary-based (1957) Model for Interpersonal Teacher Behaviour (Wubbels, et al., 1985).

The model describes interpersonal teacher behaviour along two dimensions: Influence (DS, or Dominance–Submission) and Proximity (CO, Cooperation–Opposition). The Influence dimension represents the degree of dominance or control displayed by the teacher, while Proximity describes the level of cooperation between teacher and students. The two dimensions can be represented in a co-ordinate system divided into eight equal sectors (see Figure 1). The sectors are labelled DC, CD, and so on, according to their position on the graph. The sectors of the model describe eight different behaviour types: Leadership, Helpful/Friendly, Understanding, Student Freedom, Uncertain, Dissatisfied, Admonishing and Strict.

Figure 1. The Model for Interpersonal Teacher Behaviour.

The Questionnaire on Teacher Interaction (QTI) was developed in The Netherlands in 1984 to gather student and teacher perception data (Wubbels et al., 1985) based on the Model for Interpersonal Teacher Behaviour. Research with the QTI has resulted in a vast and evolving knowledge base on teacher-student interpersonal behaviour (Fraser, 1998; Levy, den Brok, Wubbels, & Brekelmans, 2003; Wubbels & Brekelmans, 1998; Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006). The QTI has been reliably and extensively used in a host of countries, such as The Netherlands, Australia, the United States, Israel, Korea, Singapore, Brunei, Indonesia and India, among many others.

Using data gathered with the QTI, researchers in The Netherlands derived a typology of interpersonal teaching styles (e.g., Brekelmans, Levy & Rodriguez, 1993; Wubbels, Brekelmans & Hermans, 1987). A graphical display of the eight types is presented in Figure 2. The eight types can be characterized by means of the two dimensions in the Model for Interpersonal Teacher Behaviour (see Figure 3). The Authoritative, Tolerant/Authoritative and Tolerant profiles are patterns in which students perceive their teachers relatively high on the Proximity Dimension, with the Tolerant type lowest on the Influence Dimension. Less cooperative than the three previous types are the Directive, Uncertain/Tolerant, and Drudging profiles, with the Uncertain/Tolerant type lowest on the Dominance Dimension. The least cooperative pattern of interpersonal relationships is demonstrated by the Repressive and Uncertain/Aggressive types. Repressive teachers are the most dominant of all eight types.
SUBJECT-RELATED DIFFERENCES IN TEACHER-STUDENT INTERPERSONAL BEHAVIOUR

A small number of studies have investigated subject-related differences in students’ and teachers’ perceptions. In one study from the USA (Levy et al., 2003), using multilevel analysis and investigating a large number of other variables as well, differences were found in students’ perceptions on QTI scale scores according to the subject taught. Students in science/math classes perceived their teachers lower on the Leadership and Understanding scales than students in all other subjects, while students in social science classes (Geography, Economy, History) perceived their teachers as more Uncertain than students in all other subjects. Effect sizes in the Levy et al. (2003) study were strong and represented about half a standard deviation in scale scores.

Den Brok et al. (2004) compared students’ perceptions of Physics and English (EFL) teachers on two separate samples representing these subjects. Using only dimension scores they found Physics teachers to be perceived less cooperative and slightly less dominant than EFL teachers. They also found differential effects of teacher-student interpersonal behaviour on student outcomes between the two subjects: interpersonal behaviour seemed to have a larger effect on pleasure and confidence for physics teachers, while it had a larger effect for EFL teachers on achievement scores and perceived relevance of the subject. Differences in perceptions and differential effects on outcomes were related to the nature of the school subject by den Brok et al. (2004): they argued that students had more opportunity to practice languages (EFL) outside school (internet, television) than to practice physics, and suggested that in many EFL classes small tasks with many subtasks were used, requiring much corrections by teachers. The latter may have explained why EFL teachers were rated higher on dominance and why less variance in dominance was found in the EFL sample compared to the Physics sample. The authors acknowledged these arguments to be highly speculative.

Wubbels and Levy (1993) discussed subject-related differences in students’ and teachers’ perceptions comparing both data from the USA and the Netherlands. They found mathematics teachers to be most dominant of all subjects, together with foreign language teachers, while social science teachers were perceived as least dominant. These patterns were found both in students’ perceptions as well as in teachers’ self-perceptions. Differences were most prominent for the Strict scale and for the Student Freedom scale. They also interviewed the teachers as to why these differences might have occurred. Teachers argued that in math and foreign language classes whole-class instruction occurs more often than in other subject classes, requiring stronger adherence to and enforcement of class rules. Moreover, the teachers argued that their subjects required much corrections (in the case of languages both on content and linguistics), resulting in higher dominance (and lower cooperation) perceptions.

RESEARCH QUESTIONS

In this contribution, the following research questions are investigated:

- What differences in students’ perceptions of teacher Influence and Proximity can be found between teachers of science subjects and teachers of (all) other subjects?
- What differences in teachers’ self-perceptions of teacher Influence and Proximity can be found between teachers of science subjects and teachers of (all) other subjects?
To what degree can different (distributions of) interpersonal profiles be found in teachers’ and students’ perceptions of teacher-student interpersonal behaviour between science teachers and teachers of other subjects?

METHOD

Sample

To investigate the above research questions, we reanalysed an already existing data base on students’ and teachers’ perceptions of the interpersonal behaviour of teachers in Dutch secondary education. The data pertains to QTI data collected during the school years 2004-2005 and 2005-2006. The use of an existing data base implied that only limited information was available with respect to background characteristics of respondents.

Students’ perceptions on the QTI were collected with 44,353 students, located in 1,820 classes from 605 teachers in 201 secondary education schools from all across the Netherlands. Teachers of these students taught different school subjects, but 8,503 students (19.2 percent) reported perceptions on science teachers; distribution within the science domain were as follows: 1,497 students in Physics (17.6 percent), 1,466 students in Chemistry (17.2 percent), 3,228 in Biology (38.0 percent) and 2,312 in Mathematics (27.2 percent).

In total, self-perception data were available for 910 teachers and 1,797 of their classes. Distribution across school subjects was as follows: 390 science classes (21.7 percent), containing 67 Physics classes (17.2 percent of the science subject classes), 72 Chemistry classes (18.5 percent), 148 Biology classes (37.9 percent) and 103 Mathematics classes (26.4 percent).

Instrumentation

All respondents completed the original, Dutch 77-items version of the QTI (Wubbels, et al., 1985). The items are answered on a five-point Likert-type scale. These items are divided into 8 scales which conform to the 8 sectors of the model. Table 1 presents a typical item and the number of items for each scale.

Table 1
Number of Items and a Typical Item for the QTI-Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Typical item</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Leadership</td>
<td>S/he is a good leader</td>
</tr>
<tr>
<td>CD Helpful/friendly</td>
<td>S/he is someone we can depend on</td>
</tr>
<tr>
<td>CS Understanding</td>
<td>If we have something to say s/he will listen</td>
</tr>
<tr>
<td>SC Student freedom</td>
<td>S/he gives us a lot of free time in class</td>
</tr>
<tr>
<td>SO Uncertain</td>
<td>S/he seems uncertain</td>
</tr>
<tr>
<td>OS Dissatisfied</td>
<td>S/he is suspicious</td>
</tr>
<tr>
<td>OD Admonishing</td>
<td>S/he gets angry</td>
</tr>
<tr>
<td>DO Strict</td>
<td>S/he is strict</td>
</tr>
</tbody>
</table>

In the study presented in this chapter we analyze the teacher-student relationship on the basis of dimension scores. To summarize the scale scores by means of dimension scores we use linear combinations of the scale scores. We designate the 2 linear combinations of the 8 scores as an Influence (DS)-score and a Proximity (CO)-score. The higher these scores are, the more dominance (DS) or cooperation (CO) is perceived in the behaviour of a teacher. In addition to dimension scores we use graphic representations of the 8 scale scores ("interpersonal profiles") to report on the teacher-student relationship.

Analyses

To answer the first research question, multilevel analyses of variance were performed with MLN for Windows. In these analyses, three levels were distinguished in the data: student, teacher-class and school. Influence (DS) and Proximity (CO) were used as the dependent variables. Three models were fitted to the data. First, outcomes for empty models were established, showing the amount of variance in the two dimensions at the three different levels. Next, a subject model was fitted, in which school subject (science versus other subjects) was entered as independent variable. Finally, a model was fitted in which apart from school subject a number of covariates was taken along, namely school type track (two variables, intermediate general secondary education as binary variable (1 meaning the school type to be ‘true’) and pre-university education as binary variable (pre-vocational education was used as the baseline), student gender (1 being male, 0 being female), experience (1 being...
beginning teacher, 0 experienced teacher) and grade level (running from 1 to 6, higher numbers representing higher grade levels).

In a similar fashion, teacher self-perceptions were also analyzed with multilevel analyses of variance. These analyses contained two levels, being teacher-class and school. Again, three similar types of models were tested. The third model contained only school type track and teacher experience as covariates.

For the third research question data were first aggregated to the teacher-class level for the student perception data set. Then, scale scores were compared to an existing interpersonal typology (see Wubbels, & Levy, 1993; Wubbels et al., 2006) and classes were allocated to the interpersonal profile to which they resembled most. In a cross-tabular analysis, the distribution of profiles between science classes and other subject classes was compared (using the Chi-squared statistic).

RESULTS

The outcomes of the multilevel analyses on students’ perceptions of their teachers’ interpersonal behaviour show an interesting pattern. With respect to Influence, it can be seen in Table 2 that science teachers are perceived significantly lower on the Influence dimension, and this remains after the inclusion of covariates. The difference in perception between science teachers and other teachers is quite strong, it explains 1.2 percent of the total variance (which corresponds to one third of the total variance explained by all variables). Moreover, the effect size of subject is equally high compared to school type track (pre-university) and grade level, but higher than the effect size of gender and lower than the effect size of teacher experience.

Table 3 shows that variance distribution between levels is roughly similar for Proximity compared to Influence. Science teachers are not perceived lower on the Proximity dimension compared to colleagues of other subjects when considered as the only explanatory variable, however, its effect becomes significant after inclusion of all covariates (with science teachers perceived lower). The effect of school subject is not very strong, it explains no variance in the dimension score and its effect size is equal or lower compared to the effect sizes of the other (significant) covariates.

Table 2
Results of Multilevel Analyses on Students’ Perceptions of Influence (DS)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Empty model Coef (s.e.)</th>
<th>Subject model Coef (s.e.)</th>
<th>Total model Coef (s.e.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (constant)</td>
<td>.13 (.02)</td>
<td>.15 (.02)</td>
<td>.27 (.02)</td>
</tr>
<tr>
<td>Subject (1=science)</td>
<td>-.11 (.03) *</td>
<td>-.10</td>
<td>-.07 (.03) *</td>
</tr>
<tr>
<td>Intermediate school type</td>
<td>-.01 (.01) *</td>
<td>-.05 (.01)</td>
<td>-.05 (.01)</td>
</tr>
<tr>
<td>Pre-university type</td>
<td>.01 (.00)</td>
<td>-.17 (.07)</td>
<td>-.17 (.07)</td>
</tr>
<tr>
<td>Gender (1=male)</td>
<td>-.03 (.01)</td>
<td>-.09</td>
<td>-.09</td>
</tr>
<tr>
<td>Experience (1=beginner)</td>
<td>10.1 %</td>
<td>8.9 %</td>
<td>8.4 %</td>
</tr>
<tr>
<td>Class</td>
<td>40.2 %</td>
<td>40.2 %</td>
<td>38.0 %</td>
</tr>
<tr>
<td>Student</td>
<td>49.7 %</td>
<td>49.7 %</td>
<td>49.7 %</td>
</tr>
<tr>
<td>Explained</td>
<td>0.0 %</td>
<td>1.2 %</td>
<td>3.9 %</td>
</tr>
<tr>
<td>-2Loglike</td>
<td>23582.95</td>
<td>23566.15</td>
<td>23438.11</td>
</tr>
<tr>
<td>Diff Loglike (df)</td>
<td>16.80 (1)</td>
<td>128.04 (9)</td>
<td></td>
</tr>
</tbody>
</table>

Note: *=not significant (at .05).
### Table 3
**Results of Multilevel Analyses on Students' Perceptions of Proximity (CO)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Empty model Coef (s.e.)</th>
<th>Subject model Coef (s.e.)</th>
<th>Total model Coef (s.e.)</th>
<th>Effect size</th>
<th>Effect size</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (constant)</td>
<td>.68 (.02) *</td>
<td>.69 (.02) *</td>
<td>.55 (.03) *</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subject (1=science)</td>
<td>-.04 (.04) *</td>
<td>-.02</td>
<td>-.09 (.04) *</td>
<td>- .05</td>
<td>- .05</td>
<td>- .05</td>
</tr>
<tr>
<td>Intermediate school type</td>
<td>.03 (.02) *</td>
<td>.02</td>
<td>.02</td>
<td>- .03</td>
<td>- .03</td>
<td>- .03</td>
</tr>
<tr>
<td>Pre-university type</td>
<td>.10 (.02)</td>
<td>.07</td>
<td>.07</td>
<td>- .07</td>
<td>- .07</td>
<td>- .07</td>
</tr>
<tr>
<td>Gender (1=male)</td>
<td>-.07 (.01)</td>
<td>-.05</td>
<td>-.05</td>
<td>- .05</td>
<td>- .05</td>
<td>- .05</td>
</tr>
<tr>
<td>Experience (1=beginner)</td>
<td>.06 (.08) *</td>
<td>.03</td>
<td>.03</td>
<td>- .03</td>
<td>- .03</td>
<td>- .03</td>
</tr>
<tr>
<td>Grade level</td>
<td>.05 (.01)</td>
<td>.10</td>
<td>.10</td>
<td>- .10</td>
<td>- .10</td>
<td>- .10</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School</td>
<td>2.6 %</td>
<td>2.6 %</td>
<td>4.2 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Class</td>
<td>43.8 %</td>
<td>43.8 %</td>
<td>44.0 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Student</td>
<td>53.6 %</td>
<td>53.6 %</td>
<td>53.1 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Explained</td>
<td>0.0 %</td>
<td>0.0 %</td>
<td>0.4 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2Loglike (df)</td>
<td>67458.24</td>
<td>67457.23</td>
<td>67128.65</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diff Loglike (df)</td>
<td>1.01 (1) *</td>
<td>328.58 (9)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: *=not significant (at .05).

When teachers’ self-perceptions are considered, Table 4 seems to suggest that science teachers perceive themselves slightly (but significantly) lower on the Influence dimension; however, the subject effect disappears after the inclusion of covariates. Moreover, the effect size of subject taught is marginal and the total amount of variance explained in Influence is minimal (0.6 percent).

In Table 5 it can be seen that teachers in the science subjects perceive themselves similar to teachers of other subjects when considered as the only explanatory variable, but they perceive themselves significantly less cooperative when other covariables are entered into the model. Although the overall effect of subject taught seems to be minimal (no variance is explained), its effect size is larger than the effect size of all other covariables.

### Table 4
**Results of Multilevel Analyses on Teachers’ Self-perceptions of Influence (DS)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Empty model Coef (s.e.)</th>
<th>Subject model Coef (s.e.)</th>
<th>Total model Coef (s.e.)</th>
<th>Effect size</th>
<th>Effect size</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (constant)</td>
<td>.15 (.01) *</td>
<td>.15 (.01) *</td>
<td>.19 (.01) *</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Subject (1=science)</td>
<td>-.002 (.001) *</td>
<td>-.002</td>
<td>-.001 (.001) *</td>
<td>- .001</td>
<td>- .001</td>
<td>- .001</td>
</tr>
<tr>
<td>Intermediate school type</td>
<td>.00 (.00) *</td>
<td>.00</td>
<td>.00</td>
<td>- .00</td>
<td>- .00</td>
<td>- .00</td>
</tr>
<tr>
<td>Pre-university type</td>
<td>.00 (.00) *</td>
<td>.00</td>
<td>.00</td>
<td>- .00</td>
<td>- .00</td>
<td>- .00</td>
</tr>
<tr>
<td>Experience (1=beginner)</td>
<td>-.30 (.03)</td>
<td>-.25</td>
<td>-.25</td>
<td>- .25</td>
<td>- .25</td>
<td>- .25</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School</td>
<td>100.0 %</td>
<td>99.4 %</td>
<td>93.4 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Class</td>
<td>0.0 %</td>
<td>0.0 %</td>
<td>0.0 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Explained</td>
<td>0.0 %</td>
<td>0.6 %</td>
<td>6.6 %</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>-2Loglike (df)</td>
<td>-517.90</td>
<td>-522.98</td>
<td>-622.93</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diff Loglike (df)</td>
<td>1.01 (1)</td>
<td>328.58 (9)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: *=not significant (at .05).
Table 5
Results of Multilevel Analyses on Teachers’ Self-perceptions of Proximity (CO)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Empty model</th>
<th>Subject model</th>
<th>Total model</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef (s.e.)</td>
<td>Effect size</td>
<td>Coef (s.e.)</td>
</tr>
<tr>
<td>Mean (constant)</td>
<td>.88 (.01)</td>
<td>-</td>
<td>.89 (.01)</td>
</tr>
<tr>
<td>Subject (1=science)</td>
<td>-.04 (.03)</td>
<td>*</td>
<td>-.04</td>
</tr>
<tr>
<td>Intermediate school type</td>
<td>-</td>
<td>.04</td>
<td>-.04</td>
</tr>
<tr>
<td>Pre-university type</td>
<td>.04 (.02)</td>
<td></td>
<td>.04</td>
</tr>
<tr>
<td>Experience (1=beginner)</td>
<td>.07 (.05)</td>
<td>*</td>
<td>.07</td>
</tr>
<tr>
<td>Variance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>School</td>
<td>77.1 %</td>
<td>77.1 %</td>
<td>76.6 %</td>
</tr>
<tr>
<td>Class</td>
<td>22.9 %</td>
<td>22.9 %</td>
<td>22.9 %</td>
</tr>
<tr>
<td>Explained</td>
<td>0.0 %</td>
<td>0.0 %</td>
<td>0.5 %</td>
</tr>
<tr>
<td>-2Loglike</td>
<td>1837.16</td>
<td></td>
<td>1834.45</td>
</tr>
<tr>
<td>Diff Loglike (df)</td>
<td>2.71 (1) *</td>
<td></td>
<td>14.37 (3)</td>
</tr>
</tbody>
</table>

Note: *=not significant (at .05).

The findings of the multilevel analyses are to some degree reflected in a comparison of interpersonal profiles between science teachers and teachers of other subjects. It seems science teachers are relatively less often perceived as Directive, Authoritative or Tolerant/Authoritative compared to teachers of other subjects, but relatively more often as Tolerant and Uncertain/Tolerant. In a similar fashion, science teachers perceive themselves relatively less often as Authoritative or Tolerant/Authoritative, but relatively more often as Tolerant, Uncertain/Tolerant and to some degree Uncertain/Aggressive.

Table 6
Distribution of Interpersonal Profiles in Students’ and Teachers’ Perceptions Between Science Classes and Other Subject Classes (percentages within subject group between brackets)

<table>
<thead>
<tr>
<th>Profile</th>
<th>Student perceptions</th>
<th>Teacher self-perceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Science</td>
<td>Other subjects</td>
</tr>
<tr>
<td>Directive</td>
<td>30 (10.0)</td>
<td>245 (16.1)</td>
</tr>
<tr>
<td>Authoritative</td>
<td>32 (10.6)</td>
<td>332 (21.9)</td>
</tr>
<tr>
<td>Tolerant/authoritative</td>
<td>47 (15.6)</td>
<td>263 (17.3)</td>
</tr>
<tr>
<td>Tolerant</td>
<td>94 (31.2)</td>
<td>303 (19.9)</td>
</tr>
<tr>
<td>Uncertain/tolerant</td>
<td>57 (18.9)</td>
<td>172 (11.3)</td>
</tr>
<tr>
<td>Uncertain/aggressive</td>
<td>18 (5.9)</td>
<td>67 (4.4)</td>
</tr>
<tr>
<td>Repressive</td>
<td>- (0.0)</td>
<td>25 (1.6)</td>
</tr>
<tr>
<td>Drudging</td>
<td>23 (7.6)</td>
<td>109 (7.2)</td>
</tr>
<tr>
<td>Other/unclassifiable</td>
<td>- (0.0)</td>
<td>3 (0.2)</td>
</tr>
<tr>
<td>Total</td>
<td>301 (100.0)</td>
<td>1519 (100.0)</td>
</tr>
</tbody>
</table>

Chi-squared (df), p-value 55.75 (8), .00 64.60 (8), .00

DISCUSSION

This study investigated differences in perceptions of teachers and students regarding teachers’ interpersonal behaviour between different school subjects. For this purpose, a large existing data base was reanalyzed with multilevel analyses of variance, correcting the effect of subject for other covariates, and class profiles were created as well.

Some differences in student perceptions were found related to subject taught. Science teachers were perceived as less dominant and less cooperative (only after correction for covariates). These patterns were also found in teachers’ self-perceptions, though less pronounced and again only after correction for covariates. Nevertheless, our findings seem to converge with the few previous studies investigating this topic (though often with less advanced means and smaller data sets), such as the studies by den Brok et al (2004), Wubbels and Levy (1993).

Our results also show that subject-related differences sometimes may be hidden behind (or overlap with) other variables. For researchers it is important to realize that differences in perceptions that appear to relate to gender (distribution), teacher experience or school type sometimes may actually be differences that can be
attributed to the subject taught. Although subject-related differences appear to have modest effects on perceptions, and explain only small (or no) portions of variance, they appear as separate effects nevertheless.

A next possible step in our endeavours might lie in a more detailed analysis of subject differences. For example, what differences exist within the science domain, between subjects such as Mathematics, Physics, Chemistry or even Biology? A study comparing students’ perceptions of Turkish science students between Biology, Chemistry and Physics found significant differences between these subjects, with Physics teachers being perceived lower on both interpersonal dimensions compared to teachers of the other two subjects (Telli, 2006).

Another possible step might lie in the creation of a new study, linking perceptions of teachers and students to other relevant variables such as beliefs on the subject and the knowledge involved in the subject, prototypical images in students’ and teachers’ beliefs on their subject and subject teachers, a wider variety of personality and personal background characteristics, et cetera. Moreover, such studies could be conducted including a variety of research methods, such as interviews with students and teachers, rep grids, concept mapping, et cetera.

REFERENCES


UNDERLYING FACTORS AFFECTING MATHEMATICS ANXIETY IN SCHOOL CHILDREN

Nicholas Flegg and John Malone
Curtin University of Technology
Australia

ABSTRACT

This presentation reports on a study that investigated mathematics anxiety among school children. Public perception has always seen mathematics as difficult and many students seem to suffer from high levels of anxiety with the subject. Changes to both the methodology of teaching mathematics and the content taught have had limited success in altering this perception or anxiety level. One reason for this limited success may be that underlying factors outside of the classroom environment have not been seriously taken into account. These factors could include parental support, the physical environment, health issues and the advent of technology. This study investigated some of these underlying factors using questionnaires. Queensland students in Years 3, 7 and 8 were investigated along with parents and teachers of Years 3 and 7 students. Correlation tests were utilised, data were cross-related between the various groups and areas showing promise of being statistically significant were noted for future follow-up action. The main findings showed that underlying factors contributing to students’ anxiety included: parents’ own anxieties and the impact of these on their children; home issues including nutrition and tiredness; school transition matters; teacher attitudes and some technology issues. Differences due to the sex of students were also revealed. Areas needing further study are highlighted and recommendations to rectify the problems identified will be made for each stakeholder group.

INTRODUCTION

Anxiety towards the study of mathematics is prevalent among many school children, often caused by a range of situations both physical and emotional in the home and at school (Spagnolo, 2005; West & Varlaam, 1991; Hadfield, 1990; Jayaratne, 1987; Guppy, McMaster & Higham, 1983; Lazarus, 1966). Teaching methodology, content and relevance have all been the subject of on-going research in the context of mathematics anxiety, resulting in continual change in pedagogy, not always for the better (Mitchell & Gilson, 1997; Halpern, 1992; Weissglass, 1991; Reuman, 1989; Papert, 1980).

This study investigated possible other factors which could have been causing an underlying anxiety about mathematics, preventing the pedagogical changes from having the expected impact within the classroom. These included: ‘Home-based’ areas such as parental support, the physical environment at home, travel to school and health issues, and ‘Other’ areas such as a primary school teacher’s ability to teach mathematics well and the introduction and use of technology in the classroom. A thorough study of the literature on these and related topics was carried out, and research questions were framed (as listed in the discussion section) in order to provide the focus required for the study.

METHODOLOGY

The initial data collection administered questionnaires to 160 Queensland students, mainly in Years 3 and 7, from both State and private schools in a regional centre and the State capital. Questionnaires were also given independently to their parents and teachers and the results of the parental responses directly linked back to their own children’s responses. Ethical issues concerning working with children existed which needed to be considered carefully. Questionnaires previously developed were examined but none fitted the parameters required, so new ones were developed and checked for validity. The second survey was on technological issues only and was administered to 180 Years 7 & 8 students in one P-12 private school:

Analysis was undertaken using the SPSS statistical program. Correlation tests were utilized to investigate possible linkages between the data items. The purpose of this study was to investigate whether correlations existed and whether such correlations helped provided evidence of causation between the two linked items because of the general concern that such related factors may be exerting an influence on students. That some of the causations might be “spurious” is fully acknowledged and cross referencing was used wherever possible to minimise this likelihood. The Spearman’s Rho test uses the ranking of response and not the continuity of the data and hence was the appropriate statistical device to utilise for the initial questionnaire data, whilst the Pearson correlation test best fitted the data from the second questionnaire.
RESULTS AND INTERPRETATIONS

Summary descriptive statistics were first developed from the data so that the overall balance between the different items could be established. The following graphs show the balance between schools and sexes for the data from the first questionnaire.

Figure 1: Year 3

Figure 2: Year 7

Overall, the balance was considered acceptable for the purposes of this research. The following graphs demonstrate that the parental response rate was very good and it allowed their data to be compared to their own children’s data.

Figure 3: Year 3

Figure 4: Year 7

Year 7 responses

The first two correlations carried out were between data items where strong correlation was expected in order to help confirm that reliable data was being collected, as shown in Figure 5. These were also checked using Chi-Square tests (see Figure 6) to confirm that the item choices offered showed clear differences and were not likely to be just random variations. Both gave positive results. They compared parents and their own children’s responses to what the children had for breakfast, shown below, and to comments on liking maths. As only correlations flagged as of significance (with positive Chi-Square test results) are being reported upon, the actual figures have been omitted for the remainder of the data.

Figure 5: Correlation result

Correlation Coefficient 0.502(**)
Sig. (2-tailed) N7386**
Correlation is significant at the 0.01 level (2-tailed).

Correlation between student and parental responses in Year 7 about Breakfast using Spearman’s Rho test
The following relationships were found: If parents had anxiety about mathematics themselves, they generally have told their children about it. Anxious parents often had children who resisted attending school. Children who failed to have breakfast showed tiredness symptoms and this affected their level of work. Living a long way from school affected work levels for girls. Liking maths in Year 7 engenders a positive belief that Year 8 mathematics will not be difficult. If students are nutrition conscious, then they tend to be consistent in their eating habits by having both breakfast and lunch. Having lunch was linked both to liking maths and to showing work to their parents, which was also directly linked to liking maths.

Most showed linkages for both boys and girls, but differences of correlation level were often apparent. Some differences of opinion existed between parents and students on the issue of student tiredness where agreement was expected. Overall, home factors are clearly linked to school in various ways and hence some parents may not be providing the home environment that is needed for their children to be positive about their schooling.

Year 3 responses

For Year 3 students, some linkages similar to those from Year 7 were found, but the need to keep the language of the questionnaires much more simple limited the range of responses. Never the less, various correlations were clearly shown. Parents believe there is a direct link for their boys between liking maths and wanting to go to school although the boys themselves don’t show this link. For girls the students say that there is a link but their parents don’t clearly indicate it. Travelling long distances to school caused tiredness. Anxious parents often had children who resisted attending school. Eating healthily was linked to not wanting to attend school and liking maths. Also, students who liked maths reported that their best friends liked maths too and almost all felt that maths was their teacher’s favourite subject.

Nutrition is clearly a key area even at this age and there were differences in responses from boys and girls. There were also differences between parent and student responses on student tiredness which reinforce again that home environment issues are important.

Year 8 responses

Due to operational difficulties, there were only a limited number of responses from Year 8 students. Despite this, some results were apparent. Parents of Year 8 students who reported suffering from anxiety with maths themselves tended to tell their children about it. This correlation had high significance and reinforces the Year 3 and Year 7 results on this issue. It also provides a level of validity to the Year 8 data, despite low number of responses, as parental responses were similar for parents of all year levels. Tiredness was linked to school attendance and liking maths linked to showing work to parents. Again, both of these reinforce the need to investigate the effect of home issues more thoroughly.

Teacher responses

Responses from teachers suggested the following relationships: Female teachers had a higher rate than male teachers of disliking mathematics as a subject. For those with difficulties in their own school time, females outnumber males three to one. Teachers who dislike teaching mathematics at school had difficulty themselves at school. From the teacher’s intellectual perspective, maths was a very positive part of the curriculum but it was linked to a “lack of confidence in teaching maths”. Ten to thirty percent of their students had, in their opinion, anxiety problems. Half said that physical factors were affecting their students and just over a third felt that parents were contributing to the problems. Overall, these results confirmed the findings of studies in the literature on mathematics anxiety that showed that many teachers are maths anxious themselves, and they reinforced the responses from students and parents demonstrated earlier.
Technology questionnaire results

Figure 7 shows that there was a reasonable balance between year levels and sexes. The following results were found: Liking maths correlated with good results in maths except for Year 8 boys, which raises a question about why these boys are not achieving well despite liking the subject. Anxiety before a maths test correlated strongly with anxiety before any test, which suggests that using maths as an indicator of academic attitudes and problems, as this study set out to do, is justified. Students said that they found using a calculator easy and understood all the symbols, but in practice this is not true. Girls linked understanding the calculator to a positive view of it use. 50% of girls, but only 30% of boys, liked using one. Nearly 20% of both sexes ticked a box showing a definite dislike. There was a distinct reduction in those liking maths on transition to Year 8. Many Year 7 students said that they were anxious before tests, but Year 8 students were not. Seventy percent of Year 8 students said that they couldn’t use a calculator’s functions well. These last results indicate some worrying aspects, including attitude changes and a lack of concern over basic issues on entry to high school.

DISCUSSION

This study set out to examine factors which had little exposure in relation to their effect on student anxiety levels among mathematics students previously. These included:

- parent and student interactions on a number of issues, such as opinions about mathematics and about going to school
- health and location issues and their relationship to problems at school
- the general living conditions in which the students find themselves

This study has assumed that, as mathematics anxiety seems to be the most commonly expressed subject-specific anxiety and hence could be used as a general guide to school behaviour patterns, these other factors should correlate with it to some extent. Surveying both parents and their children was felt to increase the likelihood that responses in affective areas would provide genuine results.

Answers to the research questions

1. What are the underlying factors that affect the anxiety level of primary and middle school students towards the study of mathematics?

‘Home-based’ issues are clearly part of the problem facing students, affecting their school experience. First, parents who had anxieties with maths at school themselves generally told their own children about them and this seemed to affect some of their children by promoting anxiety. Second, the common sense idea that tiredness correlates with a lack of breakfast seems relevant here. Nutrition is clearly a key issue, relating directly to classroom performance. That some parents are not reading their children’s health issues well, nor their feelings on various school issues, directly links what happens in the home to school performance. Third, Year 3 students who liked mathematics reported that their best friend liked mathematics too, and finally the overwhelming majority of Year 3 students felt that their teacher liked mathematics - this contradicts the results of the teacher survey undertaken. Both of these link pedagogical practice to student feelings about maths.

Two major items relate to ‘Other’ issues, as defined in the introduction. First, a lack of technological expertise seems to exist in conjunction with a worrying increase in disinterest and an increasing dislike of mathematics as children progress to high school. Hence, improving students’ feelings towards mathematics could help the overall move from primary to high school. Second, the data confirmed that many teachers themselves felt maths anxious, although it was encouraging that Year 3 students had not picked up on this. Never the less, it could be adding to the stress levels of teachers themselves, with unknown consequences.

2. Are there any differences between the responses of urban and rural students or between the sexes?

This question examined at two related factors to see if they were affecting the primary issue. Urban and rural differences unfortunately lacked enough data to make valid comment, but differences in the responses relating to the two sexes were apparent. First, there were clear differences between the less positive responses shown by parents with respect to their girls and with respect to their boys, indicating that maths stereotyping is still
happening. Second, boys who liked mathematics said that they showed their school work to their parents, whereas girls did not do so. Girls indicated a higher level of anxiety about high school compared to boys, and there were differences between how parents perceived school work for boys as compared with girls. Finally, there was a positive correlation between those who like mathematics and those who achieved good results in the subject – except that boys in Year 8 did not show this correlation.

3. What actions might be taken by stakeholders (teachers, parents, students, school administrators and university lecturers) to rectify any problems uncovered?

Relevant to the research question, the following implications for teaching and learning can be made: Friendship groupings in Year 3 should be made part of group work arrangements because they promote positive attitudes among students towards their mathematics learning. Teachers of Year 3 needs to give the appearance that they like mathematics even if they do not, as it is a strategy that seems to be very effective with this age group. As boys and girls respond to situations differently, teachers should actively plan for these differences of approach. To improve competence in the use of a calculator, teachers need to introduce innovative and interesting ways of using the calculator so that its functions are utilised effectively in a wide variety of situations (not just in maths), bearing in mind that it may include teaching girls separately with different stimulus material. Assessment must follow much more closely what is actually taught, using a wider range of techniques. Teachers need to use encouragement in the classroom, especially of girls. Making mathematics enjoyable without losing its rigour may be the key to success at this level. Teachers’ telling children to do something and not mirroring the actions themselves is usually counter productive.

In addition, the following implications for stakeholders can be made. The stereotyping of mathematics with males seems to be creating problems for many children from an early age and girls are expressing more anxiety than boys - parents need to offer greater encouragement to their girls. Providing healthy and nutritious food is essential for children to get the most out of their educational opportunities – many parents are failing here. Significant numbers of children seem to suffer from tiredness and many parents are not aware of this enough to take effective action. With potentially large numbers of primary teachers, especially females, indicating a dislike of teaching mathematics, school administrators need to allocate time to discuss and to deal with the issue. Some teachers may be failing to recognise anxiety for what it is – is this a lack in their training? More innovative mathematics programmes at Year 8 level in particular are needed – time and money has to be provided. Better school to home communication is needed. University lecturers need to not only recognise that the problem of mathematics anxiety exists in many of their students but need to take effective steps to remediate the anxiety. Finally, Universities need to rethink their priorities within teacher training.

The wider significance of this research project

Previous studies carried out on maths anxiety issues in the USA reported that College and older students responded in similar ways (as did boys and girls) to questions about maths anxiety issues. Unfortunately, studies of teacher trainees reporting on their own experiences at school contradicted some of these findings, the early primary aged students had not been included, most of the home/school issues had not been researched in depth, if at all, and current technology issues had not been directly linked to mathematics problems. These four factors meant that the earlier research may have been more student specific than had been previously understood.

For Australian school children on the other hand, some differences were reported by different age groups on a variety of issues. Some major differences between the responses of the sexes were apparent and these differences started at a very early age. Hence this project has highlighted that more data, from different countries, is vital to a correct understanding of the problems associated with maths anxiety issues and has added to the store of knowledge that can be included in future research projects in this area. It also showed that home based issues played a vital role and that schools could not be expected to deal with the issues independently.

CONCLUSION

This project demonstrated that a number of hitherto unstudied issues outside of the classroom pedagogy approach previously used were directly affecting student attitudes and progress within the classroom. It identified some areas where different stakeholders could make changes which would have a direct effect on the problems encountered, some simple and easy to implement and some that required a more long term structural approach. In addition, many areas requiring further research were apparent in the findings.
REFERENCES


PROPORTIONAL REASONING: A CASE STUDY HIGHLIGHTING ITS SIGNIFICANCE IN MATHEMATICS CURRICULUM

John M Green
University of Southern Queensland, AUSTRALIA

ABSTRACT

This paper outlines a study that was undertaken with a typical thirteen year old boy. This boy was experiencing difficulty with his work on percentages, basic trigonometry and simple equation solving. Our intervention with the boy led us to suspect that there was a connection between his understanding (or lack thereof) of these concepts and his capacity to think and reason proportionally. As part of our investigation we explored several questions including “How necessary is it that a child be able to think and reason proportionally?” and “How important is this skill for the successful understanding of other mathematical concepts?” The paper documents our experiences, describing the many strategies that we used to help this boy improve his capacity to think and reason proportionally. It reports his progress over a period of several weeks, and analyses his learning and his attitude to what he was learning. Most importantly this study serves to highlight the important interrelationship between proportional reasoning and other math topics such as trigonometry, percentages and equation solving.

INTRODUCTION

There is a body of evidence suggesting that proportional reasoning is not afforded a high enough priority in the typical middle school mathematics classroom. Some researchers (Ilany, Keret & Ben-Chaim, 2004; Lo & Watanabe, 1997) highlight the importance of proportional reasoning in understanding concepts such as trigonometry, gradient, percentages and algebra. Despite such emphases the typical middle school mathematics textbook generally limits teaching of such to one chapter, and often less that this. Lamon (1995) shares this view, adding that symbols are then introduced into proportion problems before sufficient groundwork has been laid for students to understand the role of symbols in proportional reasoning problems. Also, since the topic of ratio usually leads into proportion, the situation is further exacerbated by misconceptions in ratio that can be traced back to misconceptions in decimal and fractional concepts (Pearn & Stephens, 2004; Lo & Watanabe, 1997).

We would suggest that there is a strong argument in favour of adopting a more integrated approach to the teaching of proportional reasoning. It has been suggested that this needs to be commenced at an early stage, as early as the teaching of whole number and fractions. It has been further suggested that developing proportional reasoning skills is akin to number sense or data sense, which is developed by a wide variety of experiences over time (Norton, 2005). To emphasise this, Norton used his audience at PME to pose the problem “It costs 12 cents to buy 20 straws. How much will 8 straws cost?” and it soon became evident that there were a number of methods for solving this problem, with probably the least of these being the traditional drill and practice technique of cross-multiplication.

THE CASE STUDY

Tim (not his real name) is thirteen years old and in grade nine at school. He first came to our attention through the recommendation of his teacher. We found him to be reasonably motivated yet frustrated by his failure to understand concepts that he was being taught. At the time his class was about one week into the topic of trigonometry and so we decided to focus our interview questions in this area:

Interviewer: Tim – you have been studying the expression “tan” – can you explain what it means?
Tim: Umm …… you can use it to find the side of the triangle that you don’t know.
Interviewer: Yeah – that’s correct but can you tell us what tan is? Why can it be used to find the missing side of a triangle. What is it about tan that makes this possible (hoping that he might mention the relationship between similar triangles that we know had been covered in his class)?
Tim: Umm ….

At this point we used the computer software Geometer’s Sketchpad to construct a right-angled triangle. The software was then used to record measurements for two of the triangle’s sides and the single included angle as indicated in figure 1a. Also recorded was a value for the ratio of the two sides ie 0.67. Tim noted with a degree of interest that when he clicked on the side opposite the marked angle and resized the triangle, that the ratio did not change (figure 1b). We let him play with this for awhile and then asked him if there was a situation when
the ratio was not the same. He immediately responded that this happened only when he changed the angle and he demonstrated this (figure 1c). We met Tim again the following week and picked up where we left off:

Figure 1a

Figure 1b
Interviewer: What about if you always kept the angle at 33.64 degrees?
Tim: No – the ratio won’t change .... umm .... Yeah it’s going to stay the same.
Interviewer: (Hands Tim a calculator) if I now asked you to put 33.64 degrees and press tan .... what do you think you would get for an answer on the calculator.
Tim: Would it be that ratio???(in an enquiring tone)
Interviewer: What do you think?
Tim: Yeah – I reckon it will be that ratio – yeah it will be (as he inputs the values into the calculator).
Interviewer: How did you know this so quickly?
Tim: Well .... if the angle always stays at 33.64 degrees and the triangle just gets bigger or smaller .... that ratio is going to be the same and we learnt in class how to find the tan of an angle.

We then bring up on the computer Tim’s earlier illustration (figure 1b.  We use a stickit to cover up the measurement of one of the two sides, in this case, the base measurement of 5.15.

Interviewer: Tim – we have covered up one of the sides but note that we kept the angle the same. Do you reckon you could work out what the measurement is of this side that we covered up?
Tim: Use the tan of 33.64.
Interviewer: Ok, how?
Tim: (obtains tan with calculator and writes) 3.43/x = 0.67
Interviewer: Great – now find x and you have your missing side.
Tim: 0.67 divided by 3.43 .... Isn’t it?
Interviewer: You could be right ..... why do you say this?
Tim: Well ..... it’s 3.43 divided by x here .... so x has to go to the other side ..... this is when I get mixed up .... When I have to solve an equation.
Interviewer: Ok – lets make it a little easier. Lets say that we had an angle where the tan was 0.6 exactly rather than 0.67. What is 0.6 as a fraction?
Tim: 6 tenths.
Interviewer: ok – now rewrite what you had before but with this fraction value instead.
Tim: (writes) 3.43/x = 6/10
Interviewer: 3.43 parts out of how many parts is roughly the same as 6 parts out of 10 parts. Read this backwards ....... It might make it a little easier.
Tim: Umm ..... 6 parts out of 10 parts is 3.43 parts out of how many parts. Umm ..... it would be about half wouldn’t it?
Interviewer: I think I know what you mean but try to explain it to me.
Tim: Half of 6 is about 3 …. so for 3.43 it would be about half of 10 ….. Pause
Interviewer: Keep going …. I don't mind a rough answer.
Tim: Well ….. a half of 10 ….. 5
Interviewer: Ok – so roughly 5 wouldn’t you agree. So the missing side is roughly 5 or exactly 5.15 (removing the stickit to illustrate answer ie figure 1b).
Interviewer: So 3.43/5.15 = 6/10 ….. does this make sense? Would you like to use your calculator to confirm this? (Tim uses calculator and appears happy with his result)

This experience opened our minds to the following question. Was it the trigonometry content or was it Tim’s proportional reasoning skills that prevented him from understanding this area of mathematics? We asked Tim’s opinion. He explained that only now did he understand “why the ratio stayed the same when the angle didn’t change”. When we asked him why, he said that he could “see it better when the computer was doing the calculations”. We asked if there was anything else that he did not understand from before. He explained that even though he understood the steps for finding the missing value, x, he seemed to “get it wrong a lot of the time”.

Tim appeared to be saying that he had problems with trigonometry initially because he did not understand the rationale that underpins the tangent ratio. Our observation was that he was able to formulate a “proportionality equation” which when solved would yield the missing side. He did this by following a drill and practice procedure. When it came to solving the equation he again relied on a rote memorised procedure for doing so – albeit a procedure that he was not able to adapt to cater to all situations. For all intensive purposes then, Tim was able to follow the problem through to it’s conclusion and yet here he was telling us that he did not understand what he was doing until now.

Tim’s experience in this particular instance does highlight one thing. In Tim’s case or in the case of children like Tim, there is a need to understand a concept at a conceptual level before he/she is asked to move on to more routine and algorithmic procedures. The other question that we ask is how much of Tim’s difficulties could be attributed to his proportional reasoning skills (or lack thereof)? We decided to explore this area further. We used an excerpt from Tim’s interview when he stated that it was equations like 3.43/x = 6/10 that confused him, and explained that we were going to try and see how he was thinking about such equations. (Note that at this point, we would want to caution the reader that there is a difference, conceptually at least, between a ratio and a fraction despite the fact that in many texts they are treated as being the same. What we mean by this, using an example, is that the fraction 2/5 is conceptualized as 2 parts out of the 5 parts that make up the whole. On the other hand, the ratio 2:5 may be conceptualised as the comparison of 2 parts with 5 parts, thereby leading one to conceptualise the situation as 7 parts making up the whole. We decided, nevertheless, to proceed as follows and manage this contradiction should it prove necessary.)

We used a typical paper folding exercise (figure 2) that is sometimes used for illustrating the equivalence of fractions. Tim is given this A4 sheet of paper which is representative of the common fraction 2/5. We explain that the sheet of paper illustrates the fraction two fifths because two out of the five equal parts have been shaded in. We ask Tim to fold it in such a way that what he sees now is the representation in figure 3 following.
Figure 3

Tim is able to tell us that what he sees now is the fraction 4/10 and he does so with an air of confidence. With a little direction Tim is able to readily accept the conclusion that 2/5 = 4/10. The dialogue continues:

Interviewer: If I told you that we had the equation 2/4 = x/10 then what would be the value of x?
Tim: 4
Interviewer: How do you know?
Tim: From what we just did – the paper.
Interviewer: Ok …… what if I gave you 4/10 = x/20 …. Would you know how to find x?
Tim: 8 ….. I think you’d just double the four.
Interviewer: Ok ….. that was fast …. Well done ….. show me why …. Use the sheet of paper.

We expected Tim to simply fold the sheet again along the horizontal plane just once more so that the representation would show 8/10. Interestingly Tim tried to do several folds along the vertical plane. We let him proceed. After a few minutes, it was evident that he was not getting anywhere, so we gave him a copy of the same sheet of paper that we used earlier in figure 2 and asked him to make the first fold to illustrate that 2/5 = 4/10. At this point, he made the connection and folded the sheet along the correct plane, proudly explaining why 4/10 = 8/20, going even further by attempting (with difficulty) to make one more fold in an attempt to show us why 8/20 = 16/40. We should mention that we very nearly corrected Tim before he had the chance to make that first “incorrect” fold. We would now argue that it is a good thing that we resisted the temptation to do so. Our view is that it was this process of self-correction that allowed speedier understanding as well as a sense of ownership of that understanding on Tim’s part.

We decided to stay on the topic of equivalent fractions a little longer and so we posed the following problem on cricket wicket taking averages. “Which bowler has the higher wicket taking average? Bowler A who takes 7 wickets in 10 overs or bowler B who takes 9 wickets in 12 overs?”

We asked Tim to consider what he thought Bowler A’s average might have been after 5 overs to which Tim responded “half of that wouldn’t it be …… 3 and a half”. Assuming that bowler A kept up the same average, we asked for the average after 20 overs to which Tim again correctly gave the answer as “14”. We asked Tim to write this as a proportion to which he eagerly wrote “7/10 = 14/20”. We asked Tim to use an A4 sheet of paper to illustrate that these two fractions were in fact equal. After a little thought he divided the sheet into 10 vertical strips and then shaded in 7 of these, correctly completing the task by folding the sheet along the horizontal plane (figure 4):

Figure 4

At this juncture we decided to help Tim extend this kind of thinking with the help of a spreadsheet. We were
aware that Tim had done some work in Excel and had some basic spreadsheeting skills. We gave him the following (figure 5) spreadsheet containing only (what you see in bold is all that Tim was given) and asked Tim to use it to illustrate what he had done earlier, this time for both bowlers. He needed a little prompting but this was more to do with the nature of the task than the doubling and halving aspect of this proportional reasoning task. He completed this task to our satisfaction. We asked Tim who he thought had the better average to which he responded bowler B because 4.5 wickets out of 6 overs is better than 3.5 wickets out of 5 overs. We nearly asked Tim why he thought this, but then guessing (rightly or wrongly) that he probably did not have a justifiable reason, we asked him what he thought bowler B’s average would have been after 5 overs rather than 6. Tim answer was “oh …. About 4 … I don’t know”.

Figure 5

We then varied the spreadsheet and presented Tim with the following (figure 6). Again, all Tim could see were the bolded numbers while the remaining numbers were the answers that we were hoping Tim would be able to compute with minimal assistance. We left the top halves of columns G and H blank. Tim filled in the missing values in columns F and G without any assistance. He thought about column D, left it for a minute and looked at column C, returned to column D, asked us for confirmation whether all that was required for him to get the answer was to divide 7 by 10 and 9 by 12. When we confirmed this he appeared a little bemused that the problem should be that straightforward. He then moved to column C and filled in these figures with confidence. He then moved onto column B, thought for a bit, and asked for help. We asked if he was to add what was in column C and D, whether this would give him the right answer. He seemed to accept this. He finally moved onto column H and after two failed attempts, decided for himself that adding together the values in C4 and G4 would give him the required answer.

Figure 6

We noted that now we could be truly convinced that the better average was 9 out of 12 and we asked him why we were sure of this. He responded that 37.5 out of 50 was more wickets than 35 out of 50. We asked him to
study this table carefully and then we asked him if it was necessary to use an average out of 50 for each bowler
in order to decide who had the better average? It was at this point, we believe, that Tim underwent a light-bulb
type of experience, exclaiming "just make them the same ….. as long as it is the same number of runs for each
bowler that …. Yeah ….. 2.5 out of 3 is better than 2.1 out of 3…. 1.5 is better than 1.4 …. 0.75 is better than
0.7 …. oh …. so all you have to do is just divide …. Yeah …. divide the wickets by the overs …. Wickets per
over".

When we re-visited the above transcripts after the interview we came to the conclusion that Tim was in fact
working with concepts that stretched well beyond simple proportion. There were elements of ratio, rate,
equation-solving and maybe even the idea of using percentages as a standard by which comparisons may be
made between ratios.

At this point in the paper we would like to remind readers that when we were first introduced to Tim we were
told that he did not understand the work that he had been taught on percentages. We decided that at our next
meeting with Tim we would use his understanding so far as a bridge for developing understanding in
percentages. We commenced the next session by referring Tim to the bowling averages problem and asking "35
out of 50 is the same as what out of 100" and “37.5 out of 50 is the same as what out of 100”. Tim simply
doubled these figures to arrive at the respective answers. We asked him what the connections were between
what he had just done and the topic of percentages. He confidently explained that since 35 out of 50 was the
same as 70 out of 100, this meant that it was 70%. We then asked Tim whether this is how he did it before. Tim
considered our question for a moment and then responded “…. actually …. no – that’s not the way I did it in
class. We learnt to do it like 35 divided by 50 and then times this by 100” and he proceeded to demonstrate this
on his calculator obtaining 70 as his answer. We then asked him which method he preferred to which he
responded that he preferred our method because he understood why it worked. He went on to explain that even
though he remembered to “divide and then times by 100” he would often get confused with the wording of some
questions. We asked him if our method would work for all questions and we asked him to try our method on a
bowling average of 4 wickets in 15. Tim used a doubling procedure to obtain 8/30, 16/60 and then added these
two to get 24/90 and after a pause, appeared happy to hand back the problem to us. We then asked him that
bowling average of 4 wickets in 15. Tim used a doubling procedure to obtain 8/30, 16/60 and then added these
questions. We asked him if our method would work for all questions and we asked him to try our method on a
considered our question for a moment and then responded “…. actually …. no – that’s not the way I did it before. Tim

We went on to explain to Tim that the percentage problem that he had just solved could in fact have been written
as 4/15 = x/100. We summed up what he had learnt so far by saying that the reason for first dividing the 4 by 15
was so that we are able to establish that 4 parts compared to 15 parts is in same ratio as 0.2667 parts compared to
1 part, which we then multiply by 100 in order to establish that this then is in the same ratio as 26.67 parts to 100
parts. Tim seemed pleased with himself which we took to mean that he was experiencing a sense of self-
satisfaction with his comprehension of the work. We further explained that 26.67 parts out of 100 parts is
commonly referred to as 26.67 percent (%) and it comes from the Latin derivation per centum meaning per
hundred.

The last area identified as problematic for Tim had to do with “equation solving”. This is a topic that is not easy
to teach, especially if you want to do it well. It takes some highly skilled teaching to have children develop the
required facility in this skill. There are numerous activities highlighting concepts such as backtracking,
balancing, flowcharts and function-machines that should be covered over a period of years. At this point in time
we did not feel it wise to deviate too far from the main theme of our investigation, proportional reasoning, in
order to undertake such a diagnostic task. At the same time, however, we did not want to lose a valuable
opportunity to link at least a little bit of equation-solving with the concept of proportional reasoning.

We gave Tim the proportion 2/4 = 4/8 and got him to write the cross-product for this ie 2x8 = 4x4, noting that
they were equal. We got Tim to volunteer several proportionality expressions including fractional ones such as
1.5/2 = 3/4 and illustrate to us that the two cross-products were equal. We then gave Tim 4/2 = 2/1, and Tim
applied the process to this proportion easily. We then gave Tim 15/5 = 3 and asked Tim if it was possible to
apply the procedure to this. Tim explained as he wrote “ er ….. 5x3 = 15x …. Er … there is no number here
…… ah ….. would I just put times 1?”. We confirmed that he was correct and asked how he came up with this
answer. Tim explained, “ there is no denominator for 15 so I just put 15 over 1”.

At this point we returned to the equation 4/15 = x/100, reminding Tim that he had previously worked out the
answer to this percentage question as being \( x = 26.67 \). Tim proceeded as follows:

Tim writes and explains: (writes) \( \frac{4}{15} = \frac{x}{100} \)

\[
4 \times 100 = 15 \times X \\
400 = 15X \\
\text{..... Tim pauses}
\]

Interviewer: what is 15 times 10?
Tim: 150
Interviewer: ok .... So what is 15 times 20 then?
Tim: double that .... 300
Interviewer: what is 15 times 30?
Tim: add those ....... 450
Interviewer: ok ...... so roughly 15 times what is 400?
Tim: I reckon .... About 25 ... no 26
Interviewer: that was pretty good ..... how did you know 26
Tim: oh ..... Cos .... I said 25 and then I remembered the answer was 26.6 something.

...... Tim appears to be grinning with pride

Interviewer: Would you like to see a quicker way of getting an accurate answer?
Tim: yes
Interviewer: Think of a small number less that 10 and multiply it by 2 and tell me what you got
Tim: 14
Interviewer: your number is 7 ..... how did I get that so quickly?
Tim: You doubled it?
Interviewer: Let's try another one ..... Think of an even number less that 20 and divide it by 2 and tell me what you got
Tim: 9
Interviewer: your number is 18 ..... how did I know this?
Tim: you multiplied it by 2
Interviewer: do you understand what we are doing here? Getting back to our original equation .... after I multiplied my number by 15 I got 400 so before I multiplied it by 15, I must have had one fifteenth the amount which is 400 divided by 15.

Tim: yes.

Next we gave Tim the following problem: “30 is what percent of 50?” Tim wrote the equation \( \frac{30}{50} = \frac{x}{100} \) and used this to record the cross-products \( 30 \times 100 = 50 \times X \). He then comfortably solved this equation to obtain \( X = 60\% \). We jokingly suggested to Tim that he must have been lying when he said he had trouble with percentages. Tim responded that he understood questions like this but when they were asked a different way he "get’s all confused". Our suspicion was that Tim might have been having difficulty distinguishing the part/whole and the numerator/denominator aspects of the percentage equation.

In light of this we decided to illustrate the IS/OF strategy for obtaining the correct equation. Although not widely found in the typical math text book, it is a strategy that we personally have found useful in the past. Every percentage problem has three pieces of information of which one (X) is missing. The two numerators are read from left to right followed by the two denominators to read somewhat like "something is something percent of something".

\[
\text{...... IS } = \text{ ...... } \% \\
\text{----------------- } \text{----------------- } \\
\text{OF ...... } \text{100}
\]

The student is encouraged to fill in the easiest bits of information from the question into the template above. When seen this way, it should become apparent that every percentage question can be grouped into one of the following three types.
Type 1
“30 is what percent of 50?” would be entered into the template and hence read as “30 is X % of 50”.

\[ \frac{30}{50} \text{ IS } \frac{X}{100} \]

Type 2
“46 is 20% of what number?” This question would be entered as follows and hence read as “46 is 20% of X”.

\[ \frac{46}{X} \text{ IS } \frac{20}{100} \]

Type 3
“What is 15% of 125?” This question would be entered as follows and hence read as “X is 15% of 125”.

\[ \frac{X}{125} \text{ IS } \frac{15}{100} \]

We got Tim working on a collection of percentage questions that contained a mix of the above three types of questions. In almost every case he was able to determine the proportionality equation associated with the question and then use the cross product and his understanding of equation solving so far to arrive at an answer. He got incorrect answers for only two questions and in both cases these were due to computational errors.

Satisfied that Tim could analyse percentage problems and solve the resulting equations we decided to return to trigonometry. We told Tim to research the internet and tell us when we see him next what a “clinometer” is used for. When we saw Tim again he proudly explained how it was used by surveyors to measure angles of elevation and angles of inclination and he was able to clearly explain what these terms meant. We then presented him with the scenario of having to measure the height of the flagpole by constructing a triangle and by using the tan of an angle. We helped Tim by drawing the flagpole and asked if he could use a clinometer to find any angles that he would need if he was standing a set distance from the base of the flagpole. Tim explained his thinking in the following way:

Tim: I’d measure out a distance, eg 10 metres from the base of the flagpole and get the angle from the ground to the top of the flagpole.

Interviewer: Good.

Tim: say the angle is 30 degrees and the height will be X

Interviewer: Keep going

Tim: \[ \tan 30 = \frac{X}{10} \]

Tim: \[ 0.57 = \frac{X}{10} \]

Tim: now I have to solve this ….. umm …. Cross-product …. Could I change the 0.57 to 57/100

Interviewer: yes.

Tim: ok so …. \[ 100X = 57 \times 10 = 570 \]

Interviewer: Keep going

Tim: \[ X = 57 \] ….. yeah the flagpole is 57 metres high. Must be a really tall flagpole.

Interviewer: Make sense?

Tim: Yeah … that’s interesting.

Interviewer: could we have made that 0.57/1 instead of 57/100

Tim: um …. I don’t know

Interviewer: Well – try it and find out.

Tim: \[ 0.57/1 = \frac{X}{10} \]

Tim: \[ 1X = 0.57 \times 10 = 57 \]

Tim: oh yeeah ….. the answer is the same …. It’s quicker that way cos it’s the same isn’t it ….. yeah ….. 0.57/1 is the same as 57/100 ….. I get it …. Yeah I get it now
Conclusion

This boy came to us experiencing difficulties with percentages, basic trigonometry and equation solving, and at first glance there did not appear to be a common reason for this. It was fortunate for us, however, that early in the study we began to suspect a connection between the boy’s understanding (or lack thereof) of these concepts and his ability to think and reason proportionally and it was partly this knowledge that led us, initially at least, to make the decisions that we made. It would be fair to say that this study did contain an element of action research in the sense that each new discovery resulted in us asking new questions and taking new pathways. Along the way we gained a fascinating insight into not just the challenges faced by the teacher who attempts to teach children how to think and reason proportionally, but also the critical place that proportional reasoning holds or should hold in the middle-school mathematics curriculum. Most importantly this study gives us a vivid illustration of the distinctive interconnectedness between proportional reasoning and other math topics such as trigonometry, percentages and equation solving.

The study also suggests certain implications for the profession. Proportional reasoning needs to be woven into a variety of mathematical topics in such a way that there will be ongoing connections made between not just the topics themselves but also within the skill of proportional reasoning itself. Proportional reasoning should certainly be taught in tandem with topics such as trigonometry, percentages and equation-solving. It would probably be of benefit to integrate it into other topics such as fractional understanding in the number strand and when learning about rate, similarity, gradient and even algebra.

References


ABSTRACT

Surprise is an emotional response to an unexpected event (an anomaly or discrepant event). In Piagetian terms, surprise is linked to cognitive perturbation and occurs when prior knowledge leads to expectations that run counter to immediate experience. Surprise raises the level of arousal and directs the individual’s attention toward the anomaly (orienting reflex). Heightened arousal and focused attention are precursors to information processing and memory formation. In a study that employed surprise as a teaching technique, 39 preservice nurses participated in instructional interviews about the involvement of fluid physics in nursing procedures. These interviews employed a range of such items of nursing equipment as evacuated drain bottles, intravenous giving sets, syringes and an aspirator. In addition, some other devices were employed to illustrate particular properties of fluid flow. The interviews were taped and transcribed. The study found that pertinent information accompanying the experiences of surprise and the provision of coherent explanations for the anomalies was processed and linked to changes in understanding among the participants. Additionally, the use of sequenced questions was found formative in aiding participants in learning to give explanations and make predictions. Participants expressed satisfaction in the result of their learning.

INTRODUCTION

Within the developed nations of Europe there is strong evidence to suggest that as children progress from primary schooling into the years of secondary schooling their interest in science declines (Reiss, 2007; Sjoberg & Schreiner, 2005). In contrast, students in less developed countries maintain their interest in science as they progress into the years of secondary schooling. It appears that Australia, a developed country, is not independent of this trend. For example, the numbers of students studying physics and chemistry for the New South Wales Higher School Certificate (HSC) have declined over the past decade and a half – despite the rise in total numbers of students attempting the HSC over the same period (Board of Studies NSW, 1990; 2007). There have been calls to revitalise school science teaching and to recapture the imagination of students (Green & Rood, 2005). This paper presents one means by which student curiosity can be fostered. It examines the use of surprise in relation to the topic of fluid physics in an attempt to improve motivation and provide the opportunity for learning within a group of preservice nurses. In doing so, the paper investigates the effectiveness of combining pertinent elements of information with unexpected experiences and the use of sequenced questioning as a means of scaffolding student attempts to create descriptions, explanations and testable predictions. Finally it presents the participants’ reactions to the process and to their perceptions of their own learning.

The effect of surprise

Human memory has the ability to categorise and store a record of experiences with the external world (Sternberg, 2005). This categorical organisation of memory gives rise to large thematic, functional and stable chunks of knowledge called schemata that contain related concepts and propositions (Anderson, 2000). Deductive processes within this knowledge structure permit the individual to create informed expectations about future events within particular contexts. Surprise is the emotional response to events that run counter to these expectations. This emotional response has been linked to a sense of cognitive dissonance (perturbation in Piagetian terms) in that a set of ideas that had formerly been assumed to be reliable has failed (Myers, 2006). The effect is to increase the level of arousal and to direct attention toward the source of the surprise (Engel, Debener & Kranzioch, 2006; Johnson, 2004). Arousal is a psycho-emotional state of readiness to carry out some activity as determined by an intention or the perception of an external situation (Coon, 2005; Winston, 2003). Attention is the ability to concentrate cognitive resources upon the one set of stimuli or the one activity for a prolonged period of time (Norman, 1976). Eric Kandel (2006) used terminology from William James (1890) to distinguish between two types of attention. Involuntary attention is a ‘bottom-up’ process of the implicit memory system in which some element of the environment suddenly dominates the individual’s perceptual field. The reaction to this intrusive external event, including the elevated arousal and focused attention, is termed the ‘orienting reflex’ (Western, Burton & Kowalski, 2006). In contrast, voluntary attention is a ‘top-down’ process that is related to a conscious effort to focus attention (Kandel, 2006). Curiosity can be
considered to be a state obtained when involuntary attention is converted to voluntary attention. Kandel (2006) argued that steady selective attention is a necessary precursor to the cascade of molecular activity that involves gene expression, protein formation and the resulting formation of long-term memory. However, creating long-term memory and effective learning are not necessarily synonymous.

Discrepant events

Constructivist educators have employed surprise in the form of discrepant events (Driver, 1989; Fensham & Kass, 1988; Nussbaum & Novick, 1982) or anomalous data (Chinn & Brewer, 1993a; 1993b; 1998) as a means of encouraging students to re-examine those prior ideas that gave rise to the flawed expectation. While moderately elevated levels of arousal, curiosity and focused attention are regarded as necessary precursors to information processing (Norman, 1976; Sternberg, 2005) they of themselves are not sufficient to ensure that learning will occur. Driver (1989) acknowledged this when she wrote, “even when a discrepancy is recognised, this by itself does not necessarily enable a student to replace a prior idea with a better alternative” (p. 485). Further, Chinn and Brewer (1998) reviewed their extensive data in relation to student-responses to anomalies (anomalous data or discrepant events) and developed a taxonomy of seven categories. Five categories described student responses ranging from rejection or doubt to reinterpretation of the experience to ensure conformity with their prior ideas. One category of student response indicated peripheral idea change and only one response category involved genuine conceptual change (learning).

Of the reasons that may be advanced as to why the sole use of discrepant events has little chance in causing conceptual change, two are important to this study. Firstly, students’ commonsense ideas of nature are often anchored in direct experience and as a result are invested with an authority that puts them beyond the scope of critical examination (Fensham, 1993). Because of this resistance to change, students can carry their early and entrenched commonsense ideas into their tertiary years of study (Greive, 2005). It is often the task of the teacher to free students’ understandings of these entrenched commonsense views. Secondly, an unexpected event causes surprise because the individual experiencing the event lacks sufficient background knowledge to create an appropriate expectation. Sutton (1998) argued that the features of an activity to which observers give attention depend “on the mental organization which they already have” (p. 33). Thus a lack of background knowledge can also mean that when an event unfolds before the individual, he or she is unable to identify the significant elements within the experience that are key to changing their prior ideas. Hence the individual could focus attention upon, and code into memory, those aspects of the experience that, while they are prominent, may actually be irrelevant to a more complete understanding of the event.

Capitalising on surprise

While a number of strategies have been suggested to capitalise on the advantages created by a discrepant event (for example, see Driver, 1989 or Fensham & Kass, 1988), this paper will focus on the effectiveness of those strategies that feed information, provoke thought, make connections and scaffold abilities to use existing knowledge to create explanations and to predict as yet unobserved phenomena. Driver (1989, p.485) accepted that there were situations when “overt instructional approaches designed to help learners construct new models or conceptions” are needed. However, she does argue that these approaches should build upon existing conceptual understandings and they should relate to pertinent, immediate and practical experiences. In relation to the use of overt instructional approaches, Chinn and Malhotra (2002) found that providing information about the salient features of an activity either prior to the occurrence of the activity or concurrent with it, allowed students to focus upon the significant elements of the activity. Under these circumstances they found that students tended to make observations that were more consistent with a shift in understanding.

Beyond factual recall

Understanding is more than the recall of factual information – it involves the use of factual information to create descriptions, explanations and make predictions about the potential outcomes of unobserved events. Schank (2003) argued that explanations are narratives in which “the situation being described . . . [is] characterised . . . in terms of . . . mental constructs that are indexed to the [factual] information already in mind” (p. 318). In other words, scientific descriptions, explanations and predictions are created when a structured cognitive entity (an executive schema that indexes intention to information) sequences factual propositions according to prescribed rules of logic. Greive (2005) used the term ‘logical narratives’ to distinguish scientific descriptions, explanations and predictions from those narratives that detail simple stories. It follows that merely adding factual information to conceptual structure or ridding conceptual structure of less productive ideas does not necessarily mean that students have the skills necessary to create logical narratives. Sutton (1998) suggests that “students should re-work scientific ideas and practise those ideas in argument and discussion” (p. 36). Similarly, Shank (2003)
argued that teachers should “teach by building on what students already know and by having students construct their own explanations” (p. 318). Where students have difficulty in creating their own explanations, they may benefit from observing teachers model the process and from having their attempts to explain or predict scaffolded by sequenced questioning.

In summary, surprise can capture involuntary attention, but learning is likely to occur only if the teacher is able to capitalise on the moment, create sufficient curiosity to hold voluntary attention long enough to supply pertinent information and aid students in developing the skills to use that information in creating logical narratives.

Research questions

The fore-going review raises the following questions:

Can the occurrence of surprise created by discrepant events be coupled with:

  i) the supply of timely elements of information;
  ii) teacher-modelling the production of logical narratives and;
  iii) teacher-scaffolding of student efforts to create logical narratives;

...to foster learning in a one-to-one situation with students?

What effect does this process have on student-attitudes and motivation?

METHOD

This study deals with the nature of individual understanding and individual learning, and hence involves a careful examination of the way participants describe and explain phenomena pertaining to fluid physics. These phenomena were created by having the participants operate a range of devices illustrating various situations involving fluid flow (see Figure 1). Hence the most appropriate way of obtaining data was the use of one-on-one ‘interview about instance’ employing a semi-structured approach with interviews being taped and transcribed. This method has a long history of use (Clough & Driver, 1985; de Berg, 1990; Novick & Nussbaum, 1978; Psillos & Kariotoglou, 1999). Interviews followed the procedures laid down by Johnson and Gott (1996) and triangulation was provided by the use of differing contexts provided by various devices, but illustrative of the same concept.

The interviews were divided into two phases. The first phase was investigative where students were asked to operate the various devices (see Figure 1) and their understandings of these events were questioned. The second phase was deliberately instructional and the objective was to observe learning take place. Here elements of information were intermingled with questions. Students were asked to explain why certain phenomena occurred and their explanations were scaffolded by sequential questioning. In like manner, student-predictions about unobserved outcomes were also scaffolded by sequential questioning.

A total of 39 preservice nurses (12 males), ranging in age from 18 to 27 years and older, participated in the study (see Table 1). They were spread from the first year to the third year of their course and included three pre-service graduates. Each participant was assigned a code-name to hide their identity and the study had the approval of the Curtin University of Technology Human Research Ethics Committee.
Figure 1. The devices employed in the interviews involving the principles of fluid flow.

Table 1
Participants Sex, Age and Year of the Nursing Course

<table>
<thead>
<tr>
<th>Year of Course</th>
<th>Males</th>
<th>Females</th>
<th>Totals</th>
<th>Age</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>18 - 20</td>
<td>21 - 23</td>
<td>24 - 26</td>
<td>27 &amp; over</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>10</td>
<td>14</td>
<td>7</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>6</td>
<td>10</td>
<td>16</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grads</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals</td>
<td>12</td>
<td>27</td>
<td>39</td>
<td>12</td>
<td>14</td>
<td>5</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RESULTS

In order to present a view of learning that occurred as a result of exploitation of instances of surprise this section will organise the results in the following way. Firstly, it will provide an overview of the initial understandings of the participants in relation to fluid physics. Secondly, it will provide evidence that the respondents experienced surprise. Thirdly, it will examine instances of surprise and trace some examples of interactions with participants in which the instance of surprise appeared to lead directly to conceptual change. Fourthly, it will examine situations in which moments of surprise were evoked during the scaffolding of predictions and their effects. The fourth and final section of the results will deal with evidence that learning took place and the participants’ reactions to their realisation that learning had occurred.

Initial understandings of fluid physics

The investigative phase revealed that of the 39 participants only eight held views about fluids and fluid dynamics that could be construed as being cohesive and reasonably consistent with a scientific perspective and of these only one held a fully defensible understanding of fluid physics. While the views of the remaining 31 participants were varied, they were also generally fragmented, idiosyncratic in nature and expressed in loose and often animistic language. What is more, the majority of participants exhibited a reluctance to critically reflect on the causes of commonly experienced phenomena. These details have been fully canvassed in Greive (2005).

Making use of instances of surprise

During the interviews there were in excess of 40 instances of exclamations that could be interpreted as indicators of surprise. These instances occurred in two distinct circumstances. The first was a response to an unexpected observed phenomenon. The second was also an unexpected event – the occurrences of successful student-predictions. In this situation, student reasoning was scaffolded by sequential questioning and was followed by the actual phenomenon their reasoning had predicted. Each of these aspects of surprise will be examined in turn.

Surprise related to an unexpected observed phenomenon and the development of explanations

Unexpected events caught many participants off-guard and elicited responses ranging from mild comments to gasps and exclamations. These events became the focus of attention and discussion. For example when Pat broke the seal on the evacuated drain bottle (see Figure 1) below the surface in bucket of water, she did not expect that it would fill so rapidly. Her first words following the experience were, “Holy dooly! Will it fill right up? That’s cool!” Majorie thought that the water would enter the evacuated drain bottle but did not expect the rapidity with which it would fill. She initially said “Its coming.” But then exclaimed, “Oh! My heavens! There it is! I didn’t expect it to go so fast.” This activity allowed the participants to become acquainted with the effects of air pressure. It is reasonable to assume that the individuals making these exclamations were experiencing surprise.

Pat who learned about atmospheric pressure with the evacuated drain bottle, was asked to hold the siphon device (see Figure 1). She did not expect to see the fountain effect when it was set in operation. As the water began to flow, the following exchange took place.

Pat: Oh! The water’s flowing up!
Interviewer: Yep. Now what’s going on? Which way is the water flowing?
Pat: Its flowing from my beaker up into that (nodding her head toward the up-turned conical flask).
Interviewer: Where is the lower pressure then?
Pat: Up there. (Indicating the up-turned conical flask).
Interviewer: Why is the pressure lower up there?
Pause
Interviewer: What is moving down (indicating the up-turned conical flask) to create the lower pressure up there?
Pat: The level of the water [in the up-turned conical flask].
Interviewer: Right. As the level of the water drops, the volume of the air space . . .
Pat: Gets bigger.
Interviewer: . . . and the pressure?
Pat: Decreases.
Interviewer: What’s pushing the water up into the flask?
Pat: The pressure of the water down here is at a higher pressure (indicating the lower beaker).
Interviewer: What’s causing the pressure in the water down here?
Pat: The height of the water?
Interviewer: Yes but something else is more important.
Pat: The air pressure.
Interviewer: That’s right. So we are creating in here (indicating the up-turned conical flask), a pressure that is lower than atmospheric pressure.
Pat: Yeah.

Pat’s moment of surprise focused her attention on the device. The series of questions guided her thinking and scaffolded an explanation for the activity. With this assistance she identified the regions of relative pressure, identified the ultimate cause of the higher pressure and the hence the direction of fluid flow.

Toward the end of her interview, Pat was presented with an intravenous infusion bottle (IV bottle) on a stand with an air-way needle inserted into it. The tap was opened and the saline solution began to flow. Pat was asked what would happen if the air-way needle became blocked. From experience she knew that flow would cease. When asked why the flow would cease she responded with the following:

Pat: You block that (the air-way needle) off . . . and air won’t flow into the bottle . . . but it (the IV fluid) still flows for a bit . . . so the pressure inside [the bottle] drops. But the pressure down here (pointing to the receiving measuring cylinder) is still atmospheric . . . so there’s not enough pressure to push it (the fluid) through. Hey - how about that! Pretty good huh!

Pat did not need prompting to invoke atmospheric pressure in her explanation. She had learned and she felt pretty good about that! Her moment of celebration was an indication of the exhilaration that can be experienced with meaningful learning. It is akin to the ‘Aha’ experience that will be the subject of later comment. Both instances, the function of the siphon device and the blocking of the air-way needle to the IV bottle indicated the application of Pat’s knowledge to new and different contexts. Both instances demonstrate understanding.

A second example of surprise and scaffolded learning came from the interview with Sharnie. At the outset, Sharnie’s knowledge of fluid physics was minimal and fragmented. Her understanding of pressure permitted high pressure to both ‘suck’ and ‘push’. Initially Sharnie believed that water rose in the syringe because she was “pulling back” on the plunger creating “more pressure, a higher pressure” inside the syringe. This ‘higher pressure’ was a part of a “pressure gradient” that was “sucking the water up.” However, when she was asked to break the seal on the drain bottle in the bucket of water she was caught by surprise and blurted out, “Oh my goodness!” When asked if she expected the bottle to fill she said “Yes, but not nearly that much or that violently. It sort of exploded in.” When she realised that atmospheric pressure was the prime cause of the rapid filling of the drain bottle she exclaimed “You mean atmospheric pressure caused that!” Here, surprise created by the sudden and graphic filling of the bottle focussed Sharnie’s attention and emphasised the accompanying information about the magnitude of atmospheric pressure.

Later when introduced to the IV bottle with the air-way needle, Sharnie was asked what would happen if the needle became blocked. The following dialogue occurred.

Sharnie: It would stop. See I know about these things.
Int.: Why would it stop?
Sharnie: You’d be stopping the air from going in and stopping off it’s ability to equalise with the outside atmospheric pressure. There that sounds good doesn’t it. (Peals of laughter). It’s no longer normal pressure in there, it’d be a lower than normal pressure if you blocked it (the needle) and that’s why it (the flow) would stop.
Int.: So if I block the airway needle off and the flow stops the pressure inside the glass IV would . . .

Sharnie: . . . would be slightly negative. See that sounds good to! (more laughter)

As with Pat, this instance with the IV bottle indicates Sharnie’s ability to take her growing knowledge and apply it to a different context. This instance also demonstrates understanding.

**Surprise at the veracity of scaffolded predictions**

A number of participants in the interviews were led by sequenced questions through a prediction in relation to the function of some of the devices. One such device was the ‘pressure drop’ apparatus (see Figure 1). This device allows water to flow through a long horizontal tube complete with vertical rises to provide an indication of fluid pressure at different points within the horizontal tube. When the cap was removed from the end of the horizontal tube and water flowed through it. The following is an extract from the transcript of Heather, a third-year preservice nurse.

Int.: When I pull the cap off, will fluid flow through there?
Heather  Yes.
Int  Does a fluid flow from high pressure to lower pressure?
Heather  Oh yes, yes. It will be higher up there (pointing at the junction between the tube and the reservoir).
Int  And the lower pressure will be?
Heather  Yes, here (pointing at the end of the tube).
Int  What will happen to the pressure as we travel down the tube then?
Heather  It will decrease.
Int  It will decrease. If the pressure drops as we move down the tube, what will you be able to tell me about these respective heights (pointing at the vertical tubes).
Heather  The levels will be getting lower.
Int  Which one will be highest?
Heather  This one (pointing at the vertical tube nearest the reservoir).
Int  And which one will be lowest?
Heather  That one (pointing at the vertical tube nearest the end of the tube).
Int  You’ve made a prediction now haven’t you.
Heather  Yeah (laughing).
Int  Now I want you to pull the cap off the end.
Heather  Wait a minute I’ve got to think about it.
Int  Don’t think too hard.
Heather  Okay, . . . I pull it off do I? Oh maybe I’ll . . .
Int  No you’ve made a prediction, let’s test it.

Heather pulls the cap off.

Heather  Yyess!! Yeah! If I put the cap [back] on will it go back to the same levels?
Int  Try it and see.
Heather replaces the cap.
Heather  Oh Yes!
Int  Now what you did there was to logically apply the principles that you know about fluid flow.
Heather  Well initially I would have thought . . . like I would have thought that they’d all be the same level. But if that were so then the pressure inside would be all equal throughout.

Having followed through the question-answer process, Heather made her prediction but was reticent to test it. However, once she pulled the cap off and found her prediction to be correct she responded with delight. What is more, she then wished to carry out a further test. She replaced the cap and expressed satisfaction when she saw the levels in the vertical tubes return to near their original height. Finally, Heather made the connection between the vertical height of the fluid and the pressure inside the fluid within the horizontal tube immediately below the vertical tube.

The Cartesian Diver was yet another device that was used to scaffold student predictions. In the extract below, Peter was guided to predict the motion of the diver.

Int  Now, . . . I’ve got a glass bubble floating around on top of the water. I’ve got a piece of balloon over the top [of the measuring cylinder] that is sealed around [the edges] you see that? It (the measuring cylinder) is just filled with water. Notice that in the glass bubble there is a little bubble of air at the top?
Peter  Yeah.
Int  What’s going to happen if I were to squeeze in on the rubber, so that I force the rubber in appreciably, what is going to happen to the air inside? The seal is maintained.
Peter  Right.
Int  I force that (the rubber diaphragm) down into the measuring cylinder.
Peter  You um . . . will compress the air.
Int  Alright, what do you know about pressure. If I create greater pressure there, what will happen.
Peter  The volume of the air will decrease.
Int  The volume of the air will decrease, what about the pressure throughout the water?
Peter  It will be redistributed.
We’ll certainly change the distribution. What will happen to the little bubble of air in the top [of the diver] if I increase the pressure? The little bubble of air in the top - I’m going to call that thing the ‘diver’.

Uh hu.

What’s going to happen to that little bubble of air in the diver?

I guess it will probably . . . let me think . . . I know that it will either get bigger or smaller.

Well what have we done, we’ve squeezed on that, increased the pressure. If the pressure has increased what’s going to happen to the air space?

The air space will be decreased.

If it’s decreased, what’s going to fill it?

Water.

What’s going to happen to the density [of the diver] if we get more water inside?

It will be more dense.

It will be more dense. If its more dense . . . if it becomes more [dense] than that of water what’s it going to do?

Sink.

Do you believe it.

No (laughing).

You don’t believe it?

I don’t believe it.

You don’t believe it?

I don’t believe it.

The rubber is pressed in and the diver sinks.

SSHUCKSS!!!!

Interviewer alternately depresses and releases the rubber diaphragm.

Now watch the bubble of air. Can you see it moving.

Yes I can.

Wow!!

You can send it right to the bottom.

Can you.

That’s fantastic! Shucks!

Let it off and the air expands and the diver rises, squeeze it in and it sinks . . . I can do what I want with it . . .

Wow.

Squeeze it in I can send it down . . . I can make it stay make it stay there. I can do what I like with it. All I have to do is change the pressure at the top and because it is enclosed, pressure is transmitted throughout the system. If I increase the pressure at the top, I increase the pressure throughout. And I can bring it back up again.

Neat.

Can you explain it?

Probably not.

Try.

Okay let me see. Now when you put pressure on the balloon . . . you transmit pressure throughout the whole system . . . and um . . . if you increase the pressure in the water, you decrease the volume in the bubble of air . . . and so when you um . . .

What moves into the diver?

Um water and when you decrease the volume and add water it (the diver) becomes denser than water and it sinks. Is that right?

That’s right.
At this point, Peter demonstrated that he has accommodated to the relationships involved and was able to provide an explanation.

CONCLUSION

Response to the research question: Surprise and the learning process

The participants in the study gave every indication of experiencing instances of surprise as they observed the outcomes of many of the practical activities. These instances were evidenced by their many and varied exclamations and comments. The dialogues that followed these occurrences indicated prolonged attention and the contrast between the participants’ initial and final conceptual states indicate that significant learning took place. The intervention that occurred between these initial and final conceptual states involved a mix of pertinent elements of information, modelling the process of logical narrative creation and scaffolding participants’ attempts to give explanations and make predictions. This study concludes that the instances of surprise created interest and curiosity that resulted in prolonged attention and hence facilitated the learning process.

There is also evidence to suggest that the supply of information helped to bring about conceptual change. However, the information was not randomly supplied. It was directly related to the device being employed and to the experience of the moment - it was pertinent information and germane to the occasion. It is likely that this enhanced the cognitive significance of the information and contributed to the conceptual change. This process was interspersed with pointed questions that provoked the participants into using their newly gained information. In other words, the process was dynamic, requiring participants to immediately relate new ideas with such elements of existing knowledge as nursing procedures or the function of nursing equipment.

The evidence provided by this paper suggests that the ability to recall factual information alone does not mean that individuals have the skills necessary to provide clear and precise explanations and predictions. The creation of logical narratives is a separate skill and was modelled before the participants and their efforts were scaffolded by the use of ordered and sequential questions. This procedure forced the participants to contemplate the logic involved and to shape the propositions that they incorporated into their narratives. During this process, the questions merely prompted the participants - they supplied the bulk of the propositions involved. Hence, the process did not provide circumstances for rote learning, it required reasoning effort on their part. The ability of the participants to internalise the process and provide careful and reasoned explanation of their own in new and different contextual events indicated the success of the scaffolding process.

Response to the research question: Effect on participants’ attitudes and motivation

Initially the participants saw little relevance in the physical sciences and exhibited an incomplete and fragmented understanding of the fluid physics (Greive, 2005). They were complacent about the need to understand the function of items of nursing equipment and initially saw little need to reflect on the background of simple routine nursing activities. However, when exposed to practical activities related to nursing and when unexpected events caught their attention in a pleasant and non-threatening environment, and particularly when these activities and events were accompanied by pertinent information, changes began to occur. Old ideas were replaced with new ideas that were more consistent with the participants’ recent experiences. As they experienced the power of ideas to explain and predict, they responded with expressions of satisfaction and even enjoyment. In Sharnie’s words, knowledge and the power of explanation “sort of changes the way you see things if you understand some of the background . . . I suppose it gives you a greater confidence.”

This paper argues that the ability to take the propositions originating from basic conceptual knowledge and weave them into logical narratives that provide coherent explanations, or even better, testable predictions, gives the individual power over the knowledge and through that, power over aspects of the external environment. The expressions of exultation by the participants could well have been due to this sense of empowerment and could well herald the beginning of an intrinsic motivation.

REFERENCES

ABSTRACT

Phenomena based on air-flow through the atmosphere can produce unexpected results that appear to be counter-intuitive. Activities based upon these phenomena can be employed to attract and hold students’ attention. These phenomena are linked to Bernoulli’s equation which is derived by viewing pressure as a potential (energy per unit volume) and employing a statement of energy conservation. A modified form of this equation permits students to directly explain and/or predict a range of outcomes related to air-flow through the atmosphere. This package of theory plus associated activities provides an excellent enrichment unit for capable upper secondary students or an effective entry point into the study of fluids for tertiary students.

INTRODUCTION

Within the realms of Australian education, physics has an image problem. In the most populous state (New South Wales) numbers of Higher School Certificate (HSC) candidates attempting physics peaked in 1991 (Board of Studies, 1991) when 13,020 out of a total of 54,347 candidates took physics (almost one in four). By 2007 the number of HSC candidates had risen to 67,189 while the number taking physics had dropped to 9,253 (approximately one in seven - Board of Studies, 2007). With the rise in the number and variety of tertiary courses in the applied sciences and technology the numbers of students entering teacher education in the sciences have declined and by 2004 the supply of science teachers had become critical with up to 75% of schools nationwide indicating difficulties in staffing their science classes (Harris, Jensz & Baldwin, 2005). Nationally, schools reported that two out of every five physics teachers did not have a major in physics and one out of every four physics teachers had studied physics for one year or less during their years of teacher education. In commenting on the paucity of supply of physics teachers, Professor Brown, Dean of Science Australian National University Canberra, said that poorly prepared teachers “lacked the skills [needed] in order to get [the] excitement [of physics] through to students” (Rood, 2005, p. 2). In order to experience that excitement in physics, students need to be exposed to the wonder of direct experience with physical phenomena. Physics can be made to tease and tantalise the interests of students when teachers create moments of surprise with phenomena to which they expose to their students. This paper follows the earlier paper by Greive and de Berg (2008) and provides an example of the use of surprise in teaching an application of Bernoulli’s equation.

Surprise is an emotional response to an unexpected or anomalous event (Winston, 2003; Myers, 2006). The human brain responds to surprise by raising the level of arousal, focusing attention upon the particular event (Engel, Debeneer & Kranczioch, 2006; Johnson, 2004), and by preferentially recording information about that event into memory (Norman, 1976). Additional information that is supplied during this period of heightened cognitive activity has an increased likelihood of being processed and recorded in memory (Chinn & Malhotra, 2002). In other words, a skilled teacher can deliberately provoke surprise within his or her students in order that new observations and associated information can be provided to students in circumstances that will maximise the likelihood that learning will take place.

SURPRISE IN ACTION

Initial exploration

A table-tennis ball placed on a flat palm and subjected to a strong flow of air will become caught in the airflow and be blown away. Yet the same ball placed within the constraints of an up-turned funnel through which a similar airflow is directed downward through the neck of the funnel will remain in place (see Figure 1).
To most students, the first event is to be expected because it is consistent with casual everyday observations. However, to an understanding based upon everyday observations, the second event is unexpected, counterintuitive and surprising, as it runs counter to everyday expectation.

**UTILIZATION OF SURPRISE**

**Background – Pressure as a potential**

Pressure is usually introduced as the magnitude of force divided by the area over which the force acts. Such a definition is usually accompanied by a diagram showing a force acting over a given surface area. This consideration does little to create an understanding of the pressure at a point within a fluid. However, pressure as the magnitude of force over area can be shown to be dimensionally equivalent to energy per unit volume (see Box 1). Thus, pressure can be thought of as the ‘energy of squeezedness’ within a fluid (McClelland, 1987). As such, the pressure at a point within a fluid becomes a measure of the potential possessed by the fluid to release energy or do work by ‘unsqueezing’ (expanding). In this sense, the energy obtained is given by:

\[ E = \int P \, dV \]

As energy per unit volume, pressure is analogous to other entities exhibiting the potential to do work, such as electrical voltage (energy per unit charge). Just as differences in electrical potential provides the energy to push charge toward points of lower potential, differences in fluid pressure also represent the ability to do work by pushing fluid from regions of high pressure to those of lower pressure.

**Box 1: Pressure as a potential**

Pressure \((P)\) is usually taught to students as the ratio of the magnitude of a force to the area over which the force acts.

\[ P = \frac{|F|}{A} \]

This definition ensures that pressure is a scalar quantity. If the numerator and the denominator are both multiplied by the same quantity, the ratio is unchanged. In this case the quantity is an element of length ‘\(l\)’.

The new expression for pressure is now:

\[ P = \frac{|F| \times l}{A \times l} \]

Now if the force ‘\(F\)’ Newton pushes through a displacement ‘\(l\)’ metre, the work done is given by \(|F| \times l\) joule. Further, area ‘\(A\)’ metre squared times height ‘\(l\)’ metre gives the volume \(A \times l\) cubic metre.

In other words, pressure is also given by energy per unit volume.

\[ P = \frac{E_p}{V} \]

Where \(E_p\) is the internal energy associated with pressure within the fluid.
Pressure and fluid flow

Consider an element of flowing fluid composed of a fixed number of molecules having a mass $m$ kg and at a particular instant occupy a volume $V$ litres and are travelling with an average velocity of $v$ m/s in the direction shown in Figure 2. The lines in figure 2 are streamlines of the flowing fluid and the central line shows the path upon which the considered element is placed.

![Figure 2: Representation of streamlines of a flowing fluid.](image)

The total energy possessed by this element of fluid at Region A is given by the sum of the energy associated with its internal pressure ($E_p$), its kinetic energy ($\frac{1}{2}mv^2$) and its increase in gravitational potential energy ($mgh$). What is more, the total energy is constant. Therefore:

$$E_p + \frac{1}{2}mv^2 + mgh = K,$$

where $K$ is a constant.

At the instant under consideration, the volume of the element of fluid was $V$ litre. Hence by dividing through by volume $V$ the equation becomes:

$$\frac{E_p}{V} + \frac{1}{2}(\frac{m}{V})v^2 + (\frac{m}{V})gh = K_1,$$

where $K_1$ is a new constant.

Now, energy per unit volume ($\frac{E_p}{V}$) represents the pressure within the element of fluid and mass ($m$ kg) divided by volume ($V$ litre) represents the density of the element ($\rho$). Therefore the energy equation becomes:

$$P + \frac{1}{2}\rho v^2 + \rho gh = K_1.$$

The form of this equation was first developed by Leonard Euler and named after his good friend and the pioneer in fluid dynamics, Daniel Bernoulli (Rouse & Ince, 1957). This derivation is consistent with those found in general physics texts (for example, Serway & Jewett, 2004).

If it is assumed that the flow of fluid is close to horizontal, then effectively changes in height are close to zero ($h = 0$). Under these circumstances the equation becomes:

$$P + \frac{1}{2}\rho v^2 = K_1.$$

This equation indicates that the pressure ($P$) within the element of fluid varies with the velocity of its horizontal flow. The pressure within the element of fluid decreases as the velocity of flow increases.

Streams of air through the atmosphere

This relationship can be applied to the flow of a stream of air through atmospheric air. Under these circumstances the constant, $K_1$, takes on more precise meaning. If the flow of the stream of air through the atmosphere ceases, then velocity is zero ($v = 0$) and the pressure within the body of air assumes the value of the atmospheric pressure in that region ($P = P_A$). Under these circumstances, the constant, $K_1$, takes the value of atmospheric pressure ($K_1 = P_A$). Hence the equation becomes:

$$P + \frac{1}{2}\rho v^2 = P_A.$$

Or the pressure within an element of air flowing through the atmosphere with velocity $v$ m/s air is given by:

$$P = P_A - \frac{1}{2}\rho v^2.$$
**Explanation of the upturned funnel**

Immediately above the ball in the upturned funnel (see Figure 1), the strong and steady airflow passed down a narrow tube at speed. However, below the ball, the funnel has widened to such an extent that the speed of airflow has been considerably reduced. Hence the air pressure in the slow moving air below the ball is sufficiently greater than the air pressure in the fast moving stream above the ball that it is held up in the mouth of the funnel.

**Further applications**

Students can be shown the two demonstrations illustrated in Figures 3a and 3b and asked to explain the effects. In the first (Figure 3a) a sheet of paper is loosely held at one edge and a stream of air is directed exclusively over the upper surface while the air immediately adjacent to the lower surface remains essentially still. The teacher can use sequential questions to scaffold students’ use of the above equation to explain their observations. That is still air exhibits a pressure equal to atmospheric pressure ($P_a$) while the pressure inside a stream of air moving through the atmosphere is reduced to a magnitude less than atmospheric pressure by a quantity equal to $\frac{1}{2} v^2$, where $v$ is the velocity of the airflow in m/s. This causes the paper sheet to deform as shown in Figure 3a.

**Figures 3a & 3b.** Two additional illustrations of the Bernoulli relationship.

In the second activity, a straw is placed in a beaker of coloured water (food colouring is a cheap and safe means of colouring the water). A second straw is used to direct a flow of air across the opening of the first straw (see Figure 3b) resulting in the column of liquid rising someway up the vertical straw. Again sequenced questioning can scaffold students’ use of the final equation (representing the adaptation of Bernoulli’s equation to air flow through the atmosphere) to explain their observations.

**Figure 4a.** Horizontal plates – the nail restricts lateral movement.  **Figure 4b.** Horizontal plates – the arrow indicates the gap between the plates.
Making a prediction

The device in Figure 4a consists of a metal tube welded to the centre of a thick metal disk such that a hole drilled through the centre of the disk lines up with the internal diameter of the tube. A second weighted disk has a short nail through the centre. The nail simply stops this second disk from sliding laterally and parting company with the upper tube and disk.

Students are asked to consider the following hypothetical situation. The upper disk is held so that the tube is vertical and the disk is parallel to the ground. While air is steadily blown down through the tube welded to the upper disk, the second and lower disk is brought parallel to and in close proximity with the upper disk (Figure 4a). The students are asked to consider and compare the pressure of the air between the two disks to the pressure of still air below the lower disk (Figure 4b). Assuming a significant speed of airflow, they are to predict what will happen when the second and lower disk is released while in close proximity to the upper disk and to give a reason for their prediction.

Additional considerations and activities

There are many more such activities that teachers can employ with their classes. They can show that two hanging balls will swing toward each other if an air stream is passed directly between them. Teachers can have students experiment with the chimney effect and they can introduce flying toys. Further, teachers can invite their students to discuss incidents from history. For example, drivers of early steam locomotives found that they could increase airflow through the firebox if they vented steam up the chimney. Students can provide a reason as to why this should happen. Finally, teachers can ask students to consider the situation of a roof during a violent wind storm.

CONCLUSION

Greive and de Berg (2008) have provided evidence that students obtain satisfaction and enjoyment from being able to explain natural phenomena and, particularly, from being able to predict the outcomes of future events. Current cognitive theory suggests that the reason for this is the opiod boost that comes from the brains own reward system (Biederman & Vessel, 2006). Resolution of a cognitive activity often results in the release of endorphins. Finally, Greive and de Berg also provided evidence that students learn to explain or predict phenomena when teachers use sequential questioning to scaffold their efforts. Activities such as this could help to regenerate student interest in physics.

This paper does not imply that the process discussed both in this paper and the previous paper (Greive & de Berg, 2008) is new or innovative. Creative teachers have used surprise throughout the long history of education. Julius Sumner Miller employed similar procedures a half a century ago (Green & Rood, 2005). This paper reminds teachers that a little creativity and drama can have a big impact on student learning. The earlier paper by Greive and de Berg (2008) provides a glimpse of new research-based understandings of why surprise has such an impact on learning. In this sense, teaching is somewhat like violin-making. Antonio Stradivari produced great violins without the knowledge of why his creations had such wonderful sound. Today the theory is beginning to provide a deeper understanding of his instruments. In like manner, recent developments in brain science have begun to provide deeper understandings of the old arts associated with teaching.

REFERENCES


ABSTRACT

Web technology has been widely adopted to assist learners with studying at a distance. Providing purely on-line curriculum has many potential advantages to both institutions and students. For students the on-line curriculum is available twenty four hours a day; there is typically on-line support and software is now available allowing access to recorded lectures. For institutions the advantages are that there are no physical or geographical limits to the number of students that can be enrolled on a course of study. However, within the field of network technology, students must actually use network devices during their studies. This is important not only because this significantly enhances student learning, but also within this field employers expect students to have practical experience. Software simulators are available but they cannot provide students with the practical experience of connecting together the physical devices. Whilst there are advantages to a ‘hands on’ approach it effectively excludes remote on-line students. ECU invested over $350,000 in dedicated network teaching laboratories which are considered to be of a ‘world-class’ standard. An access server has been used to provide remote students with access to this equipment. Significantly it is also possible to view the actual network devices by means of a webcam. Work to date has consisted of establishing the appropriate infrastructure and testing the communication links. Further trails are planned for semester 2, 2008. In effect on-line students will be able to conduct their workshops on a remotely located ‘world class’ network laboratory.

Key words: on-line curriculum, network technology, distance learning

INTRODUCTION

Distance learning became popular in the 1970s and 1980s, but until recently was conducted via postal mail. The changing nature of teaching in distance education since the 1990s has been driven by developments in technology. Since the mid to late 1990s, the World Wide Web has been used as a distributed learning mechanism, enhancing the digital learning environment to support distance and on-campus students. Using this delivery technology, teachers can provide a range of resources such as discussion forums and chat, multimedia, videoconferencing, audio and electronic blackboards to communicate with, and teach their students. These changes in distance education have been developed in an attempt to provide easier access to educational opportunities for students who are located remotely from the university, who are working or who have other constraints/commitments such as families/young children.

There has been a significant uptake of on-line education, ‘in the academic year 2001-2, five million people took at least one course online, and three million were enrolled in online degree programs’ (Kazmer & Haythornthwaite, 2005, p.7). These figures indicate that distance education online has become a popular alternative to face-to-face instruction. The opportunities presented by emerging technologies to create quality, new learning environments that provide convenience for learners who live a long way from the university/school and/or have to work at the same time, has been recognized by tertiary and more recently, secondary educational institutions worldwide (Werry, 2002). Hence, in the late 1990s and early 2000, there was a boom in the number of universities offering online courses as an option and even a number of e-universities were established. However, recent findings indicate that many of these initiatives have had mixed success.

E LEARNING

Elearning can be defined as learning in which content is provided by information communications technology (ICT), and teaching is carried out over the Internet. Sharifabadi explains elearning as “the term used to describe teaching and learning resources or experiences that are, in some way, delivered electronically” (2006, p.391). Elearning is meant to be more than just websites that contain educational
content or linear drill and practice computer software. It includes all aspects of electronic delivery. So watching an educational video; using a digital camera or a computer to edit pictures, text or sounds for a presentation or project; or using an interactive whiteboard in a lesson, can all be considered implementations of elearning. Therefore, elearning has been variously described as learning using a range of different delivery technologies and methods such as Computer Based Training (CBT), Web Based Training (WBT), electronic performance support systems, webcasts, listservs and learning management systems (LMS). Learning management systems manage the learning environment and use the technology to “register the learner, schedule learning resources, control and guide learning processes, and analyze and report on the performance of the learner” (Brown, 2006). According to these definitions, elearning then, is much more than just the delivery of content online. It attempts to emulate the learning environment found in the traditional classroom.

Research by the International Data Corporation (IDC) and Online Learning Magazine (OLM) found that 80 percent of respondent institutions used online learning courses and planned to expand these by more than 40 percent over the next two years (Asgarkhan, 2002). Over ninety percent of US public colleges offer at least one course and enrollment in these courses has increased by almost 20% this year” (2006, p.362). Research by Werry (2002) and Zemsky and Massey (2004) found that there are major issues with elearning and the success of e-universities and online courses in the US has been mixed. While current emerging research indicates that there are issues with the online delivery of tertiary subjects, elearning as a delivery mode does appear to be an increasingly popular alternative to traditional face-to-face classrooms.

ASYNCHRONOUS ELEARNING

Asynchronous methods use collaborative tools that enable students to communicate with their teacher and their peers at any time. This communication method allows teachers to put content, course materials and feedback into the online learning system at any time that is convenient or timely for the teaching and learning program. Students can access the materials anywhere and at any time. Instructors and students can also communicate with each other at their own convenience. For example, the instructor may put up a document (lecture notes, assignment details, online reference materials, online quizzes or recent newspaper articles) or include a discussion forum posting in the learning management system for their students. The students can access the document at a later time from the computer lab, using their laptop and the wireless network, from home or from remote/overseas locations. Thus, flexibility is introduced into the teaching-learning environment and location and time of engagement with the learning materials, the instructor and other students also becomes flexible, unlike the traditional classroom.

However, asynchronous delivery is not useful when urgent help is needed. Asynchronous delivery modes such as email or discussion forums mean that students have to wait for the reply from their instructor. Feedback using these methods is not timely. Another consideration when using email or text-based interaction is the fact that it is a written exchange and there is a possibility of loss of a sense of continuity and immediacy for both the student and the instructor. Thus, it is not useful for students who wish to get feedback from their instructors in real time. There are many technologies that can deliver asynchronously such as email and discussion forums. Midkiff and DaSilva (2006) identified the benefits of using asynchronous communications as flexibility for the users, the ability to engage with different text documents and the sharing of file attachments such as weekly lecture notes in a schedule or as an attachment to a discussion forum posting. Students, who opt to complete their studies online due to work or family commitments, often value this flexibility highly (Combes & Anderson, 2006). According to Goldsmith (2001), while students tend to have different attitudes toward asynchronous communications, most students report positively about the flexibility provided by online environments, the choice to manage their own time and learning space, and the facility for detailed feedback. The major negative aspect of asynchronous methods reported by students is the lack of interaction. Raymond et al. (2005) found that using asynchronous learning environments are not interactive enough, because students get their feedback over a period of time. This lack of interaction is a major criticism of asynchronous communication methods and often leads to students having a negative opinion of online learning, particularly if this is the only method of communication used.
SYNCHRONOUS ELEARNING
Gibson, Blackwell, & Hodgetts (1998) found that synchronous communication is an effective online communication tool, in that it allows students to ask questions and get feedback in real time, just like students in the on-campus classroom. The benefit of a synchronous learning environment is that it provides immediate interaction and can mimic the immediate feedback loop that is provided in a face-to-face classroom. However, there are some disadvantages of synchronous communication, because learners all need to log in at the same time as their instructor and peers (Moore, 2001). This presents a problem when students are located in different international time zones and where working schedules or family commitments may create ‘attendance’ problems for online students. Synchronous communications also reduce the flexibility that is a feature of online learning. According to Salmon (2004) a major feature of online learning is flexibility, so students can study any time and anywhere they want. Some researchers even recommend that instructors should keep their lives simple, and use only asynchronous communications (Gibson, Blackwell, & Hodgetts, 1998). We also need to remember that synchronous communication, while happening in real time, is still text based and suffers from the disadvantages identified earlier with asynchronous methods.

So while asynchronous and synchronous communication technologies do provide opportunities for teacher-student and student-student interactions, they do not replace or effectively simulate the face-to-face environment of classical classroom instruction. Communicating by text is an imperfect medium for communication when the participants do not have the added value of body language and intonation to guide understanding and meaning. While videoconferencing and streaming video help to alleviate this problem, many students who are studying remotely do not have ready access to fast bandwidths or the technology to enable them to use these technologies easily (Yang & Liu, 2004). Students studying wholly online often experience increased levels of frustration, anxiety, lack of confidence, feelings of isolation and a lack of connectedness (Combes & Anderson, 2006). For computer science students, where the interactive nature of the teaching and learning often determines whether students master technical and practical skills, and develop complex conceptual understandings, learning in an online environment dominated by text is very difficult. Kreijnsa and Krischnerb (2003) and Soller (2001) found that interaction among students is very important in an online environment; because it is the way they communicate and learn from each other. Therefore, on-screen communication is very limiting for students who need rich exchanges of verbal cues to comprehend completely. Bullen suggests that “text-based communication does not ensure an effective online course” (1998, p.15), so while asynchronous and synchronous communications go part of the way towards solving some of the collaborative issues between teachers and students, they do not provide conclusive solutions to the problems of teacher/student and peer-to-peer interaction and immediate feedback that are a feature of the on-campus experience.

ELEARNING – PROBLEMS
There are, without doubt, advantages to providing purely on-line curriculum. However there are disciplines that must provide practical, ‘hands-on’ workshops e.g. dentistry, physiotherapy etc. The hands-on approach often used by instructors when teaching technical subject within the field of network technology practical workshops are important not only because they significantly enhance student learning, but also within this field employers expect students to have practical experience. Accordingly, ECU invested over $350,000 in dedicated network teaching laboratories which are considered to be of a ‘world-class’ standard. These laboratories are designed to emulate a standard commercial network environment. As such each student group is provided with access to a variety of different network devices such as routers, switches, firewalls, wireless access points etc all housed in standard telecommunication racks.

Whilst there are advantages to a ‘hands on’ approach it effectively excludes remote on-line students. Software simulators are available but they cannot provide students with the practical experience of connecting together the physical devices. It is however possible to provide access to network devices using an access server.

REMOTE, ‘HANDS–ON’ WORKSHOPS
An access server was purchased and configured to provide remote access to the dedicated network equipment at ECU to staff at Nakhon Phanom University. It is important to use an access server because when standard remote access protocols such as telnet are used the connection is lost when rebooting the device.

The dedicated network laboratories at ECU were allocated an IP address. There are obviously security issues hence remote access to the ECU equipment was via Secure Shell (SSH). This is a network
protocol that allows data exchange over a secure channel. SSH uses public key cryptography to authenticate remote users and is typically used as a means of logging onto remote devices in order to execute commands. Furthermore, a Terminal Access Controller Access-Control System (TACACS) was used in conjunction with a syslog server for computer system management and security auditing.

A simple network consisting of two routers and two PCs at ECU was cabled together (Diagram). None of the routers were configured and hence the two PCs could not communicate. A staff member at Nakhon Phanom University was provided with a topology map of this network and also instructions of how to access this experimental network. Using an access server, in conjunction with SSH, TACACS and syslog, it was possible to provide a secure interface to Nakhon Phanom University. This interface was identical to one that would be used if the equipment is accessed within the ECU dedicated network laboratories. Using this interface a staff member at Nakhon Phanom University was able to configure both routers and hence establish communication between the two PCs. Furthermore, using the access server it was possible to not only configure devices remotely but also reboot them without losing connectivity.

During these connectivity trials communication between both universities was via email. This successfully allowed communication between both universities. Even though the staff member at Nakhon Phanom University was an experienced network engineer it took considerably longer to configure the network than normal. Even though instructions were provided there is a need for email communication. We are currently testing Voice Over IP (VOIP) and webcam communication to support remote device access.

CONCLUSIONS

There are many advantages to online curriculum. However, within the field of network technology, employment prospects are considerably enhanced by practical, ‘hands-on’ knowledge – something not possible with standard online courses. Furthermore, network equipment is expensive and may be beyond the means of some universities. In order to address these problems a secure communication link was established between Nakhon Phanom University and the dedicated network teaching laboratory at ECU. Using this link a member of Nakhon Phanom University was able to remotely configure network equipment at ECU. Further more extensive trials are currently being planned in order to evaluate both the pedagogical and logistical issues of providing remote access to a large group of students.

ACKNOWLEDGEMENTS

Thanks to Ajan Jim Yeanan at Nakhon Phanom University for assisting in these trials.
References


IDENTIFYING SOCIAL BARRIERS IN TEACHING COMPUTER SCIENCE TOPICS IN A WHOLLY ONLINE ENVIRONMENT

Yuwanuch Gulatee  
Barbara Combes  
Edith Cowan University, Australia,

ABSTRACT

In an attempt to provide educational opportunities for students who have other constraints on their time such as working, family commitments or who are located at a distance, many universities have developed wholly online distance education programs. These online courses use web technology as a distributed learning mechanism. However, online distance learning in Computer Science courses remains challenging for both teachers and students. Research has shown that there is a significant risk factor for students studying online courses in Computer Science. To develop competence, students are required to acquire complex conceptual understandings, while learning the highly technical components of a scripting language, which they then must practically implement to solve programming problems and thus produce a program that works. Hence, the final aim of a programming course is to produce a student who has a programming mindset, which enables them to ultimately program in any language. Thus for technical subjects, instructors need to interact more when teaching students and encourage them to seek new sources of information to avoid creating limitations due to nature of the subject materials. Thus, the curriculum designers and teachers need to be aware of the particular needs of Computer Science students when establishing online courses, if they wish to graduate successful and satisfied students. This paper examines some of the social barriers to the effective teaching of computer science topics in an online environment from the perspective of instructors and learners.

Keywords: elearning, computer science, social barriers

Introduction

Over the last ten years, Web technology has been adopted to assist learners with real-time studying at a distance. Initiatives to connect into the ‘power of the Web’ as a mode of delivery for distance education programs to enhance quality and improve accessibility for education and training is evident around the world (Pye, 2003), as educational institutions and business recognise the potential educational benefits and the flexibility of online learning (Salimi, 2007; Shelley, Swartz & Cole, 2007). Consequently, Web delivery has grown rapidly and has been used as a vehicle for learning. A recent research survey shows ‘that elearning has become an increasingly important delivery format and may even dominate training in the near future’ (Kim, Bonk, & Zeng, 2005, p.1). Universities are no exception to this trend. As funding for tertiary education has become increasingly competitive and tied to student placements, the availability of online courses that can be accessed from anywhere and at anytime has become an attractive option (Tabatabaei, Schrottner & Reichgelt, 2006). Technology is being used to attract distance education students with the promise of access to more up-to-date and complex learning materials in a learning environment that is advertised as equitable with the on-campus experience.

In an attempt to provide a range of equitable educational opportunities for students who are working or who have other constraints on their time, many universities have developed wholly online distance education programs (Hentea, Shea, & Pennington, 2003). In the past distance education was generally conducted via postal mail. Now the World Wide Web (WWW) is being used as a vehicle for distance and distributed learning. It enables the use of new learning formats such as multimedia, video and audio resources delivered by Learning Management Systems (LMS) such as Blackboard and WebCT. Hence, Kazmer and Haythornthwaite (2005, p.1) found that ‘in the academic year 2001-2, five million people took at least one course online, and three million were enrolled in online degree programs’.

However, little active research appears to have been completed on issues and students’ response to the online study experience. For many universities a primary consideration is cost effectiveness and accessibility to a wider student population. Other issues equally as important include ‘the achievement and maintenance of quality in online learning delivery; ensuring access and equity in the delivery of programs; and establishing practices which can enable online learning to be sustained and to grow as a mainstream activity in university teaching and learning’ (Oliver, 2001). In order to ensure that quality assurance goals are met, universities need to look carefully at the programs, the technology and how students respond to this new learning environment. This
paper examines some of the social barriers to the effective teaching of computer science topics particularly technical subjects, in an online environment from the perspective of instructors and learners.

LEARNING AS A COMMUNITY EXPERIENCE

While there has been little research into student learning experiences in the online environment there have been a number of studies examining first year experience (FYE) and student transition to tertiary level educational environments. These studies investigated first year retention rates in traditional university environments to ascertain what conditions predicated success at university. They provide an important insight into the traditional face-to-face learning environment at tertiary level and some of the problems experienced by students. With the growing popularity of online courses and use of the Web as a delivery platform, these studies also highlight probable issues and risks for students studying wholly online.

A study conducted in 1994 the Committee for Advancement of University Teaching (CAUT) (Beder, 1998) was revisited in 1999 to establish the major patterns of stability and change from 1994 to 1999 (McInnes, 2000). In the earlier study, major issues for first year students included “developing an appropriate identity, becoming socially integrated into the university and attaining learning and generic skills and qualities such as critical thinking and intellectual rigour” (Beder, 1998). In the 2000 report these issues had changed little. Students still reported feelings of isolation, being unprepared for university academically, dissatisfaction and a lack of motivation to study. Major issues continued to be anxiety, poor adjustment to university culture and a lack of continuity of curriculum (Latham & Green, 1997). Other issues identified included academic expectations and an increasing diversity within the student population. Academics expect students to be independent learners who have good time management and information literacy skills (McInnes, 2000). This is often not the case.

Another transition issue for first year students related to learning preferences and expectations. Research reports that students prefer face-to-face instruction, interactive lectures and group-based activities (Sander et al, 2000). Students’ preferred learning style included a strong preference for teacher-led teaching and learning, but with active participation by students. In the updated CAUT review, a significant number of students reported that the use of Web-based resources and interactive multimedia to deliver course materials, particularly online discussion forums and virtual tutoring, were rare (Curtin University of Technology, 2003). While students appreciated access to online learning materials and opportunities to use technology in the classroom, they welcomed these technologies as an enhancement to the more traditional learning environment provided by the lecturer, not a replacement (Oliver & Omari, 2001).

Most of this research examines transition issues and first year experience at university for on-campus students only. If on-campus students are experiencing problems with feeling isolated, a lack of identity and feeling part of a community, then how do distance students studying wholly online deal with these same issues? If students preferred learning style is face-to-face interactive instruction and small group-based activities with Web-based resources as an enhancement to the curriculum, how do distance students who have no choice about the delivery of learning materials cope in an online learning environment?

The CAUT Review concluded that forming a student identity is closely related to feeling connected to and integrated with the university. However, the Review also reported that the proportion of students who manage to attain this sense of identity is expected to fall with an increase in flexible delivery, online courses and students who choose not to attend on-campus lectures due to work commitments (McInness, 2000). The FYE studies conclude that being a member of a learning community is an extremely important predictor of success in a tertiary learning environment where students must be more independent learners.

ONLINE LEARNING AS A COLLABORATIVE EXPERIENCE

Little research been completed on how students feel about online learning especially how their first experiences affect future learning. According to Salmon:

… many students are concerned about working online. They see reduced social contact in learning contexts as a real threat. They are anxious about the lack of stimulus and fun from their ‘buddies’ and on the potential loss of a special relationship with their teachers, trainers and professors. (Salmon, 2002. p. 5)

This preference for face-to-face communication is strongly related to students establishing a sense of identity and feeling connected and integrated with the university (McInnes, 2000). For students working entirely in an online.
learning environment where communication is text based and there are no visual cues, establishing a sense of identity and community is a difficult task that requires time. Tu and Corry (2001) suggest that there is a threshold of familiarity when studying with computers. Students need time to establish an online self and an online social presence. Students may also need time to re-establish this online presence with each new group they encounter in the online environment. Salmon also tells us that “experienced participants introduced to an unfamiliar online learning platform will still go through a familiarisation, access and motivation stage” (Salmon, 2002, p. 12). For students studying entirely online establishing a personal identity and feeling part of the university community is an ongoing issue that is revisited every time they begin a new unit with a different set of individuals.

Other issues faced by students studying online include student readiness. For online learning programs to be successful students need to have technology skills, ready access to technology, computer literacy skills and they need to be self-regulated learners. Online learning is often more student-centred and problem-based and student success depends largely on self-motivation, being able to learn independently and self-regulation of their own learning (Oliver, 2001). A lack of motivation, poor computer literacy skills and an inability to self-direct their learning is also an issue for on-campus students. However, on-campus students have access to a range of support mechanisms such as orientation programs, learning advisors, student mentoring schemes and faculty student groups. While it is possible to present similar programs online, research shows that on-campus students fail to take advantage of these services (Beder, 1998). This fact may be due to a lack of knowledge or because students do not have the confidence to utilise these facilities. In this instance, if such programs were offered online, lack of confidence may not be a significant issue in an environment that doesn’t rely on face-to-face communication.

A small case study by Hara and Kling (1999) examined student reactions to studying a course wholly online. They found that student anxiety and frustration had a major effect on student learning. A lack of prompt feedback, ambiguous instructions contained in the learning materials and technical problems markedly diminished student satisfaction and inhibited educational opportunities. The researchers criticise current research into online learning environments as too positive and for a lack of attention to studying student perceptions and response to this mode of study. In another study of first year students’ emotional response to studying online, isolation and lack of identity were identified as major impediments to success. Other factors included lack of confidence, frustration and anxiety, where lack of confidence, feelings of isolation and anxiety were closely related. The findings from this study concluded that the lecturer is a central figure in the online learning environment. Prompt feedback and early and consistent contact with students tends to counter-balance students’ need and preference for face-to-face instruction as identified in the literature (Combes & Anderson, 2006). The results of these studies indicate that studying online tends to increase students’ feelings of isolation and anxiety levels, problems identified in FYE studies as being major impediments to student success in tertiary education.

Learning in a traditional classroom is a collaborative experience between the learner and the teacher and the peer group. The isolation imposed on the online student due to the nature of the delivery mode, has been identified as a major factor that determines success at university. These feelings of belonging also extend beyond a sense of being part of a learning group in a class to also belonging to a wider learning community at university or having a ‘university experience’. These aspects of the learning environment are very difficult to simulate online, where the learner is physically removed from both the on-campus experience and fellow classmates.

ONLINE LEARNING IN COMPUTER SCIENCE

Distance learning in the field of computer science topics, particularly in technical subjects such as programming languages is even more challenging. For the majority of students, computer programming courses are more difficult and time consuming than other courses (Sheard, Macdonald, Hagan, & 1997). Programming languages can be more difficult to learn than other topics not only for beginners, but also for experienced programmers (Deek and Espinosa, 2005). Computer science programming is highly technical in nature, which may impede students’ ability to learn independently in a fully online environment. Much of the focus in an online environment is on learning independently, because staff intervention and/or assistance is usually not available at the point of need. Thus, there are some questions that need to be answered: How do we teach online and what works in the online environment and what does not? (Kazmer & Haythornthwaite, 2005).

There is little evidence that the effectiveness of Web-based learning includes a process to solve complex problems (Hentea, Shea, & Pennington, 2003). It would seem that it is currently very difficult for technical subjects to be taught wholly online, because students find it very difficult to understand the subject content and ways of demonstrating cause and effect. Students have difficulty in visualizing abstract concepts and dislike the lack of social interaction commonly found in face-to-face classrooms (Mcsporran & King, 2005). Learning is
more effective when interaction occurs between learners and teachers (Hentea, Shea, & Pennington, 2003). Research by Jehng and Chan (1998) indicates that computer programming is an area that contains complex knowledge and abstract concepts which challenge an individual and require more mental effort to learn and understand. Students in computer science have to learn programming subjects which involve several cognitive abilities including syntactic knowledge, conceptual knowledge and strategic knowledge (Bayman & Mayer, 1998). Deek and Espinosa (2005) show similar findings in studies of programming courses, where they believe that studying subjects such as programming languages are difficult, because the courses have been designed without attention to human-computer interaction. Other research by McSporran and King (2005) also supports the idea that cognitive development does not occur in isolation. In most computer science topics such as programming, the syntax of the language has complex rules that are difficult to learn and understand (Lischner, 2002). Novice programmers find introductory programming courses frustrating and difficult (Deek & Espinosa, 2005). As a result, in online programming classes, students find it more difficult to apply the theory of programming problems than in the traditional face-to-face classroom (Hagan & Lowder, 1996). Students studying wholly online need to develop learning strategies, understand language syntax and utilize their problem-solving skills to creatively solve programming problems or to create new programs, as well as be able to troubleshoot when the program does not work as expected. McSporran and King (2005) maintain that cognitive development and the development of conceptual understandings rarely occurs in an isolated environment. Hence, studying computer science topics in an online environment is very difficult for the students who are usually studying in isolation.

As a result, programming students are at significant risk of failure or leaving the course when attempting to study wholly online (Hentea, Shea, & Pennington, 2003). To develop competence, students are required to acquire complex conceptual understandings, while learning the highly technical components of a scripting language, which they then must practically implement to solve programming problems and thus produce a program that works. The final aim of a programming course is to produce a student who has a programming mindset, which enables them to ultimately program in any language.

**SOCIAL INTERACTION AND LEARNING**

Research has found that the social aspects of the learning environment are extremely important for the development of higher order thinking skills and for deep learning to occur. ‘Collaborative learning leads to deeper level learning, critical thinking, shared understanding and long term retention of the learned material’ (Kreijnsa, Kirschnerb et al., 2003, p.3). Study environments that involve collaborative learning will assist students to be more successful learners. Soller (2001) also found that students learn more effectively in groups where they encourage each other to ask questions, explain, exchange and justify their opinions, express their reasoning, building social relationships, group cohesion and reflect upon their learning.

Learners also exhibit a number of different learning styles that affect how they interact and engage with the learning materials. Traditional classrooms rely on learning by text and to some degree by listening, where learners were largely passive participants. However, visual learners learn well using image-rich teaching materials and tools; auditory learners learn well by listening to lectures, discussion and communicating with teachers and the other students; textual learners learn by reading and writing and using textual resources, while kinesthetic learners learn by practicing and having access to hands-on experiences (Lujan & DiCarlo, 2005). Most students learn more effectively when programs incorporate learning experiences that include multiple learning styles. Thus, when designing on-campus and online programs, lecturers should provide appropriate learning approaches for their students that cater for a range of learning styles, especially for online learners who do not have the benefit of the teacher being present (Lujan & DiCarlo, 2005).

Honigsfeld and Dunn (2006.) maintain that a person’s biological makeup and personal characteristics affect how they learn and respond to different types of instructional techniques. These researchers identified gender, student achievement levels and the age of students, as influences affecting their engagement with the learning environment. Research by Mupinga, Nora, & Yaw focuses on learning styles, expectations and the needs of online students. They found that most online courses are more suitable for independent learners. Most students who study online are attracted by the convenience, availability and flexibility of the class schedule and not necessarily because the format or delivery mode suits their learning style (Mupinga, Nora, & Yaw, 2006). Online students expected to communicate with their teachers and their peers. They wanted course materials to be easy to navigate and they needed to be provided with rich resources to study independently. This research also indicated that understanding the expectations, needs and learning styles of their students, will help teachers to provide better teaching-learning programs (Mupinga, Nora, & Yaw, 2006).
Research conducted by Chen and Toh’s (2006) indicates that a significant positive effect on study in an online environment, can only be attained with proper instructional design to achieve learning outcomes, irrespective of students’ learning styles. Thus, the design of online course materials appears to be extremely important for student success. Meisalo, Sutinen & Torvinen (2002), Benty-Marom, Saporta & Caspi (2005) and Sanders & Morrison-Shetlar (2001) all found that the relationship between learning styles and program design is a major influence on study in an online environment. These researchers maintain that instructors must understand student learning styles before designing online programs that use a range of delivery techniques. Meisalo, Sutinen & Torvinen (2002) found that the type of subjects taught in a virtual class also impact on the success of online programs. Their work indicates that online programming courses need to provide more practical challenges and include delivery methods rich in support from instructors, just as in face-to-face teaching. In addition, students in this research found studying independently in an online environment particularly difficult, especially in programming languages courses (Meisalo, Sutinen & Torvinen, 2002). Students preferred to have face-to-face teaching, especially on complex topics such as arrays and loops, which are difficult concepts for them to evaluate by themselves. Thus, online programs require a range of learning activities, challenges and delivery modes to create rich learning environments and to ensure that online students are supported throughout their learning.

The role of the instructor in an online environment involving a virtual programming course is also very important (Meisalo, Sutinen & Torvinen, 2002). While catering for a range of learning styles is important in all teaching-learning environments, it is very difficult to cater for all learning styles in the online environment, due to the amount of time, effort and communication issues involved. Not all types of teaching content are suited to all learning styles, nor are they easily transferable to the online environment. Computer science subjects require teachers to deliver information using a variety of teaching techniques that cater for the range of learning styles. Computer science students must be able to master complex text, symbolic language and syntax; they need to be able to visualize solutions to problems and develop schematic designs for programming solutions; and they need to develop practical skills to input data, skim and scan code on a screen and write a program that works according to the specified requirements. Computer science students may have a preferred learning style, but to become proficient in areas such as programming, database design and AI, they must also develop a range of skills across learning styles. While audio, text and visuals, including animation, can be provided in the online environment, students still find this skill development very challenging. For students studying technical subjects such as computer programming, a lack of immediate feedback is a major issue that affects understanding and deep learning.

Thus for technical subjects, instructors need to interact more when teaching students and encourage them to seek new sources of information to avoid creating limitations of the subject materials (Hentea, Shea, & Pennington, 2003). As in the FYE studies, teachers working with online students need to provide continuous support. While online learning utilizes technology that enables students and teachers to interact with each other, teaching online courses to large numbers of students is problematic. Large student numbers increase the difficulty of keeping constant and consistent communication channels open with online students. Lecturers may not be able to provide the personalized support that is a feature of face-to-face classrooms to all students in large online classes. The nature of the online environment means that students requiring immediate assistance to correct a misunderstanding may not receive it, especially where asynchronous communication is being used. Therefore, the online environment itself, presents social barriers to learning highly technical subjects such as computer programming.

**Teaching approaches, Computer Science and elearning**

Traditional classroom or face-to-face teaching provides students with opportunities to work with experts in their field of study. In a traditional classroom setting concepts become immediate and personal through students’ interactions with both their teachers and other students. These traditional interactions contribute social and emotional focus that gives students a chance to compare themselves in terms of performance, problems and priorities. Traditional classes also give students a chance to benefit from other students’ questions, mistakes and insights. In the broadest definition, face-to-face tutorials tend to have two main parts:

1. ‘a diagnostic component, in which instructors clarify students’ progress with respect to coursework, answer questions, and reflect on a previous assignment;
2. a lecture or problem-solving component, in which instructors elicit discussion on examples and issues, or in which students solve and discuss problems’ (Petre & Price, 1997, p.126).
In the wholly online environment the student is physically isolated. None of the body language and ready/immediate access to the teacher’s knowledge at the point of need is available. A major problem with teaching computer science topics on the Web is the lack of direct interaction in teaching and learning activities and immediate access to the teacher. Matzen and Alrifai found that forty-five percent (45%) of the students in their research agree that it is more difficult to teach computer science on the Web than most other disciplines, especially introductory programming (Matzen & Alrifai, 2006).

There are issues that need to be considered when teaching programming languages, because these approaches are often not compatible with elearning. Due to the nature of elearning, where students and the instructor are located in different places geographically, it is impossible for the teacher to teach the students on a one-to-one basis as often happens in the programming classroom. The hands-on approach often used by instructors when teaching programming languages is very difficult to simulate in the online environment. When working on programming students need to have instant feedback, opportunities to share information and problem-solving strategies. Programming courses require students to set up software to execute their programs using the available platform provided by the university. If each online student is using a different platform such as UNIX, Windows or Linux, this fact may cause unknown problems or difficulties, even though the students are using the same software. Thus, when problems occur while coding the program, the instructor and student may be discussing the same problem, but from a different programming environment, thus creating difficulties in understanding and communication. Traditional classroom teaching methods that rely on face-to-face, one-to-one, hands-on learning experiences are difficult to simulate in the online environment. Thus computer programming which uses these instructional methods to cope with the complexity of the subject material are difficult to transfer online.

Strategies for developing online programs that provide a socially interactive learning environment that caters for different learning styles, provides feedback from peers and teachers and opportunities for hands-on learning experiences, involve complex program design. Traditionally, online courses have consisted mostly of text on screen where traditional materials have been transferred online as PowerPoint slides, lecture notes and text-based workshops. Elearning should not just be ‘a simple electronic transposition of traditional material, presented through inflexible interaction schemes and slovenly interfaces but it should be designed based on processes and activities which have well-established pedagogical models and outcomes’ (Ardito, Costabile, De Marsico et al., 2005, p.272). Communication is mainly asynchronous via discussion forums/bulletin boards, with some real-time chat. A major disadvantage of synchronous communication is the necessity for everyone to log in at the same time as their lecturer and peers. This presents a problem when students are located in different international time zones and where working schedules or family commitments may create ‘attendance’ problems for online students. While synchronous communications represent an attempt to mimic the face-to-face classroom, they also reduce the flexibility that is a feature of online learning. Due to these difficulties some researchers recommend that instructors should keep their lives simple, and use only asynchronous communications (Gibson, Blackwell, & Hodgetts, 1998).

While asynchronous and synchronous communication technologies do provide opportunities for teacher-student and student-student interactions, they do not replace or effectively simulate the face-to-face environment of classical classroom instruction. Communicating by text is an imperfect medium for communication when the participants do not have the added value of body language and intonation to guide understanding and meaning. While videoconferencing and streaming video help to alleviate this problem, many students who are studying remotely do not have ready access to fast bandwidths or the technology to enable them to use these technologies easily (Yang & Liu, 2004). For computer science students, where the interactive nature of the teaching and learning often determines whether students master technical and practical skills, and develop complex conceptual understandings, learning in an online environment dominated by text is very difficult. Kreijnsa and Krischnerg (2003) and Soller (2001) found that interaction among students is very important in an online environment, because it is the way they communicate and learn from each other. Therefore, on-screen communication is very limiting for students who need rich exchanges of verbal cues to comprehend completely. Bullen suggests that ‘text-based communication does not ensure an effective online course’ (1998, p.15). So while asynchronous and synchronous communications go part of the way towards solving some of the collaborative issues between teachers and students, they do not provide conclusive solutions to the problems of teacher/student and peer-to-peer interaction and immediate feedback that are a feature of the on-campus experience.

A SUCCESSFUL ONLINE DELIVERY MODEL?

A successful online delivery model should include a range of student resources, facilitator resources and facilitator support such as online course materials, discussion groups, real-time lectures, learning guidelines,
textbooks and access to facilitators. Teachers should also be looking at Web 2.0 technologies and social networking tools such as weblogs and wikis which allow groups of students to interact and study in a more collaborative environment. Some universities are also creating learning materials using virtual reality software such as Second Life in an attempt to simulate the face-to-face experience. While learning management systems such as BlackBoard and WebCT provide the facility to upload a variety of learning materials with a range of interactivity, lecturers not only need to develop and include these types of materials, but more importantly, they also need to have the skill to moderate and work as online tutors to enhance interaction with students. Students consistently identify interaction and communication with the teacher as a major component for success in the online environment.

Leung (2003) evaluated his research into online learning by using the percentage pass rate for each subject and gathering the students’ perspective using the focus groups. Using the focus groups to understand the students’ perspective limits the results of this research to this specific group and the findings might not be representative across all disciplines and may not reflect the attitudes of all students using the online learning environment. However, the results of Leung’s (2003) research show that students attending traditional classroom lectures have a higher pass rate, even though the satisfaction of both the online and the on-campus class were quite similar. The methods and tools for delivering the online course included both asynchronous and synchronous communication techniques between students and teachers and students (Leung, 2003). Students in the sample group in this research also had very strong backgrounds and experience in information technology. Therefore, what might be easy for experienced users may be very hard for beginners attempting to study programming courses online.

Other research has found that to successfully design online educational programs, the teacher must ensure that there is a balance between guidelines provided by the system and the human facilitator, learning materials use a visual process of inquiry, learners are motivated with the right questions, engaged with various activities, and are provided with clear guidance (Lim, 2001). Smith and Tavers (2005) also identified interaction with the teacher as the most important factor for students in elearning; with eighty-five percent of students reporting that they felt insecure, isolated or confused because of the absence of an instructor in online study. In this research project ninety-five percent of lecturers said they spent a lot of time replying to online student queries. Since synchronous methods emphasize/simulate a one-to-one style of communication, researchers found that this delivery mode created a lot of intensive work for the teachers, far more than the oral exchange in a face-to-face class.

Methodologies used to provide elearning are a concern, because the technology available for program delivery needs to cater for students who have different characteristics such as cultural background, technical experience, access to technological equipment and different levels of physical/cognitive abilities. Therefore, it is necessary to provide the widest range of methodologies and technologies when designing elearning programs. For example, elearning should use a blend of technology and a variety of delivery modes, such as using both synchronous and asynchronous methods for communication. A report by the European open, distance and elearning stated that ‘elearning has to be oriented at the learners’ needs and situation. No longer general criteria or the same guidelines for all learners can be applied but individual learning services are needed that support learners according to their subjective preference profile’ (Ehlers, 2004). Elearning should be easier to reuse because it is designed for a dynamic environment. However, The European open, distance and elearning report acknowledged:

‘the situation today is not only characterized by the importance of knowledge and information, but the acquisition and application of it and the ability to generate, process and communicate knowledge and information using technological tools, skills that have to be developed according to personal preferences and usage contexts’ (Ehlers, 2004).

Research has found that tutor support is extremely important from the students’ perspective. There are many ways to support students online, for example by e-mail, discussion forums, chat sessions, video and teleconferencing. However, the most commonly used of these technologies still depends on using text as a means of communication. Communicating by text is an imperfect medium for communication when the participants do not have the added value of body language and intonation to guide understanding and meaning. While an avatar in a virtual environment may simulate the real person, the mode of communication is still removed from the face-to-face experience. For computer science where students must master technical and practical skills, and develop complex conceptual understandings, communicating with the instructor by text is often very difficult. So while asynchronous and synchronous communications and use of virtual technologies solve some the communication issues for study in an online environment, these methods do not provide conclusive solutions to all the problems associated with teacher/student and peer-to-peer interaction and immediate feedback, that is so much a part of the on-campus experience. In the case of programming language subjects which are usually
laboratory-based using hands-on tutorials and problem-based activities, differences in software versions and user platforms can create additional communication difficulties for the instructor trying to support the online student. Peer-to-peer communication with other students also becomes problematic.

Another important issue which needs to be considered in the development of elearning course materials is usability. Students must have different ways to learn and interactions between students should be as natural and intuitive as possible. While some elearning programs use the newer social networking Web 2.0 technologies to provide interaction between students and teachers, using these technologies does not necessarily mean that the program will be successful in the online environment. Online programs need to include an integration of teaching-learning strategies, materials and technologies that are easily accessible by all students. As well as requiring a set of features specific for successful elearning, the system interfaces must ‘provide a comprehensive idea of content organization and of system functionalities, simple and efficient navigation, advanced personalization of contents, and clear exit’ (Ardito, Costabile, De Marsico et al., 2005, p.273).

Conclusion

Creating successful learning environments at tertiary level include a complex mix of social and academic factors. Students working independently not only need to feel they belong to a wider learning community, but they also need and prefer to have the closeness and social interactivity provided in a face-to-face learning environment. As online learning continues to become a more popular alternative, it is also increasingly being perceived as an equitable experience to on-campus. However, the online teaching-learning environment is different to the face-to-face experience and both students and their teachers need to recognise this fact. Learners need to be independent, pro-active, self-motivated and have good management skills. To design an efficient and motivating online educational strategy, teachers need to concentrate on the goals and needs of the learners. Moreover, to develop elearning systems successfully, experts from a variety of areas need to be involved in the development process, for example educational/pedagogical experts, technical experts, students and classroom teachers.

When elearning programs are carefully designed to facilitate and support independent learning with a range of learning materials that cater for different learning styles, using a range of different delivery modes, then students may experience a learning environment that approaches the traditional classroom. However, the elearning environment introduces problems and difficulties for both instructors and students, particularly when using teaching methods such as hands-on activities, group work and one-to-one instruction that are difficult to transfer to the online environment. Research indicates that instructors need to be aware of these issues, be prepared to offer a different level of support for online students and design their learning materials and assessments accordingly. The importance of the social aspects of learning cannot be underestimated. For online learning programs to be successful, educators need to recognise the limitations of the technologies and the delivery mode, while at the same time designing programs that offer a range of rich learning materials. While teaching technical subjects in Computer Science online remains problematic due to the nature of the subject, with good program design and dedicated teachers who contact their students consistently, the capacity to provide deep learning outcomes for students is not insurmountable.

References


TEACHER-STUDENT INTERACTIONS IN A TECHNOLOGY-SUPPORTED SCIENCE CLASSROOM ENVIRONMENT IN RELATION TO SELECTED LEARNER OUTCOMES: AN INDIAN STUDY

Adit Gupta
Model Institute of Education and Research
India
Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT
The ultimate goal of teaching is to assist students to become independent and self-regulated learners capable of taking their own decisions. During this process the teacher has to perform many roles with the main focus being on communication with students. Thus, teaching and learning can be considered as a communication process. This communication process depends on the effectiveness of the interpersonal behaviour of the students and teachers. In modern educational scenarios, technology is playing an important role not only in helping to establish this communication but also to enrich it. This study reports the use of the Questionnaire on Teacher Interaction (QTI) for assessing the students’ perceptions of their teachers’ interpersonal behaviour in a technology-supported science classroom environment in an Indian school. Analysis of data obtained from 705 students from 15 classes provides evidence for the reliability and validity of the questionnaire in Indian settings for use at the secondary level. The same data are also used for studying gender differences and the associations between students’ perceptions of their teachers’ interpersonal behaviour with three learner outcomes i.e. their attitude towards science, academic efficacy and academic achievement.

INTRODUCTION
The Teacher is considered a central figure in any classroom learning environment especially in Indian school settings where the teacher controls the teaching learning process and directs the activities of students on a day to day basis. Thus the interaction which teachers have with their students determines the nature of their interpersonal relationships and enables the teacher to improve their teaching practices. Today teachers and students spend a substantial amount of time interacting with one another in the classroom. Educators are of the opinion that the classroom learning environment becomes more progressive if the teachers and students share a healthy relationship. Getzels and Thelen (1960) suggested that teacher-student interaction is a powerful force that can play a major role in influencing the cognitive and affective development of students. With the advent of technology in the field of education at all levels, classrooms are now becoming technology-rich learning environments involving modern information and communication technologies thereby impacting teacher-student interpersonal behaviour. This presents information on the teacher-student interactions in a technology-supported science classroom in relation to three learning outcomes which are attitude towards science, academic efficacy and academic achievement.

OBJECTIVES OF THE STUDY
The main objectives of this study were: a) to establish the reliability and validity of the Questionnaire on Teacher interaction (QTI) (Wubbels & Levy, 1993) for use with urban Indian secondary school students; b) to investigate associations of students’ perception of their teacher-student interactions with attitude towards science, academic efficacy and academic achievement in a technology-supported science classroom; c) to investigate whether gender differences occur in students’ perception of their teacher-student interactions in a technology-supported science classroom.

BACKGROUND OF THE STUDY
The studies using the QTI as an instrument have demonstrated that the nature of the relationship between a teacher and his/her students is an important aspect of the learning environment (Fraser & Walberg, 1991) and despite being a very recent instrument the behaviour patterns that are established in a classroom learning environment are relatively stable over time (Brekelmans, Holvast, & van Tartwijk, 1990; Fraser & Walberg, 1991). Creton, Wubbels, and Hooymayers (1993), Wubbels, Creton, and Holvast, (1988) and Fraser (1991)
suggested that the circular communication processes that consist of behaviour as well as determine behaviour develop early in the year in a classroom. Once these behaviours have been developed and stability has been achieved in the classroom both students as well as teachers resist change.

It has been suggested that students and their teacher should have interacted at least for a period of two to three months prior to the administration of the QTI to a target group as the items ask questions about the teacher's behaviour over a long period of time, not just during the current lesson (Brekelmans, 1989; van Tartwijk, Brekelmans, & Wubbels, 1993). It is also assumed that the nature and patterns of the teacher-student interpersonal behaviour that are established during this time are very likely to remain relatively stable for the remainder of the year (Fraser & Walberg, 1991). This conveys that the student teacher interaction nature and patterns will remain the same if the questionnaire is administered after the initial two to three months settling-in period (Brekelmans, 1989). However, for the study described in this paper the survey data were collected towards the end of the academic session when students and teacher interaction patterns were well established.

The QTI (Wubbels & Levy, 1991, 1993) was designed to assess teacher-student interpersonal behaviour in secondary classrooms and developed out of a need to measure secondary students' and teachers' perceptions of teacher behaviour. In the early 1980s, the original version of the QTI in the Dutch language was developed in four trials in The Netherlands and had 77 items, which were arranged in the eight scales corresponding to the eight sections of the model for interpersonal teacher behaviour (Wubbels, Creton, Levy, & Hooymayers, 1993). Nine to eleven items were included in each of the eight scales. Later, an American version of the QTI was developed in the English language, and had 64 items (Wubbels & Levy, 1991). The items deleted from the Dutch version were on the basis of correlation analysis of the 77-item version to 64 items in the American version.

An Australian version of 48 items followed these two pioneering versions of the QTI (Fisher, Fraser, & Wubbels (1993). This shorter version has six items in each of the eight scales. Table 1 represents the nature of the QTI by providing a scale description and a sample item for each of the eight scales. This 48-item Australian version of the QTI was used for this study.

<table>
<thead>
<tr>
<th>Scale Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Extent to which teacher provides leadership to class and holds student attention.</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>Extent to which the teacher is friendly and helpful towards students.</td>
</tr>
<tr>
<td>Understanding</td>
<td>Extent to which teacher shows understanding and care to students.</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>Extent to which the students are given opportunities to assume responsibilities for their own activities.</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Extent to which teacher exhibits her/his uncertainty.</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>Extent to which teacher shows unhappiness/dissatisfaction with the students.</td>
</tr>
<tr>
<td>Admonishing</td>
<td>Extent to which the teacher shows anger/temper and is impatient in class</td>
</tr>
<tr>
<td>Strict</td>
<td>Extent to which the teacher is strict with demands of the students.</td>
</tr>
</tbody>
</table>
DESIGN AND PROCEDURE

A research and development approach was adopted for this study. The school chosen for this study was a 70 year old institute in Jammu (J&K State, India), which has over the years used various innovative methods in teaching different subjects and in recent times has taken a lead in the introduction of technology in the classroom to make the teaching learning process more meaningful and effective. Therefore, this school provided the right atmosphere to study the learning environments of a technology-supported classroom and assess students’ achievement, efficacy and their attitude towards science. The sample for the study was chosen carefully so as to be representative of the population and comprised of coeducational classes in order to permit an unbiased test of gender differences. The sample involved 705 students in 15 science classes from grade 6 to 11, spread in the age group of 11 to 17 years. The whole study was carried out in three stages. In the first stage low cost technology-supported classrooms were setup with provision of computers, televisions and digital content in general science. In the second stage, the science teachers were trained in the use technology which was followed by teaching activities for a period of eight months thereby exposing students to a technology rich learning environment. In the third phase, the Questionnaire on Teacher interaction (QTI) was administered to assess perceptions that students have of their teachers’ interpersonal behaviour in a technology-supported science classroom. The data thus collected was tabulated in an excel file and statistically analysed using SPSS.

FINDINGS AND RESULTS

Validation of the QTI

The students’ form of the Questionnaire on Teacher Interaction (QTI) was administered to 705 students, in 15 classes in a school in Jammu, who had studied science in a technology-supported learning environment to assess the student’s perceptions of their interpersonal relationship with their teachers and also to understand teacher’s behaviour in a technology-supported environment. In order to determine the reliability and validity of the QTI, three statistical computations were done. The first being the Cronbach alpha coefficient (Cronbach, 1951) which is a measure of internal consistency and analysis of variance (ANOVA) as an evidence of the ability of each scale to differentiate between the perceptions of students in different classrooms along with eta2 statistics, which provides an estimate of the strength of the association between class membership and the dependent variable. The third involved checking the circumplex nature of the QTI.

The statistical data for the QTI are presented in Table 2. The alpha reliability coefficients for the different scales of QTI using the individual as a unit of analysis ranged from 0.51 for the Strict scale to 0.79 for the Leadership scale. However, for the scale of Admonishing the alpha reliability coefficient reported a score of 0.53 which when recomputed after deleting of an item changed to 0.66. The item deleted for computation purposes was number 12, i.e., ‘This teacher is too quick to correct us when we break a rule’. This item was then deleted in the application of the QTI in the research described in the thesis. The reliability results of the QTI were consistently above 0.50. This suggested that the QTI could be used as a reliable tool (De Vellis, 1991) in Indian classroom settings.

Table 2 reports the ANOVA results showing all the eight QTI scales differentiate significantly between classes \( (p<0.001, p<0.01) \). The eta2 statistic for the QTI indicates the amount of variance in scores accounted for by class membership has also been indicated in Table 2. The scores ranged from 0.05 for the Dissatisfied scale to 0.23 for the Student Responsibility/ Freedom scale which shows that the QTI instrument is able to differentiate between students’ perceptions in different classrooms. Figure 1 represents the alpha reliability scores on the QTI in a graphical manner.
Table 2

*Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate between Classrooms (ANOVA Results) for the QTI.*

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>No. of Items</th>
<th>Alpha Reliability</th>
<th>ANOVA (\eta^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership (DC)</td>
<td>6</td>
<td>0.79</td>
<td>0.19**</td>
</tr>
<tr>
<td>Helping / Friendly (CD)</td>
<td>6</td>
<td>0.73</td>
<td>0.11**</td>
</tr>
<tr>
<td>Understanding (CS)</td>
<td>6</td>
<td>0.68</td>
<td>0.14**</td>
</tr>
<tr>
<td>Student Responsibility/Freedom (SC)</td>
<td>6</td>
<td>0.57</td>
<td>0.23**</td>
</tr>
<tr>
<td>Uncertain (SO)</td>
<td>6</td>
<td>0.68</td>
<td>0.17**</td>
</tr>
<tr>
<td>Dissatisfied (OS)</td>
<td>6</td>
<td>0.68</td>
<td>0.05*</td>
</tr>
<tr>
<td>Admonishing (OD)</td>
<td>6</td>
<td>0.53 0.66</td>
<td>0.09**</td>
</tr>
<tr>
<td>Strict (DO)</td>
<td>6</td>
<td>0.51</td>
<td>0.11**</td>
</tr>
</tbody>
</table>

**Significant at \(p<0.001\)  *Significant at \(p<0.01\)

Bef.: Before Deleted Item  Aft.: After Deleted Item  \(n=705\)

Admonishing scale: deleted item 3

![Reliability Chart](image)

*Figure 1. Cronbach alpha reliability scores on the QTI.*

A further analysis was also carried out to explore the inter-scale correlations between the different scales of the QTI. The QTI is based on a circumplex model in which the scales are arranged to form a circular pattern of the eight dimensions of interpersonal behaviour and they are expected to be correlated.
The Model of Interpersonal Behaviour (Wubbels & Levy, 1993) predicts that the correlations between two adjacent scales are highest, but correlations gradually decrease as the scales move further apart until opposite scales are negatively correlated. This pattern is reflected in Table 3 where the results of the inter-scale correlations from the study generally reflect the circumplex nature of the QTI and thus further confirms the validity of QTI to be used in Indian classroom settings. Based on data given in Table 3, Figure 2 illustrates the circumplex model, as it relates to the Understanding scale.

Table 3
Inter Scale Correlations for the Questionnaire on Teacher Interaction (QTI)

<table>
<thead>
<tr>
<th></th>
<th>Lea</th>
<th>HFr</th>
<th>Und</th>
<th>SRf</th>
<th>Unc</th>
<th>Dis</th>
<th>Adm</th>
<th>Str</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership (DC)</strong></td>
<td>0.61**</td>
<td>0.70**</td>
<td>0.32**</td>
<td>-0.10*</td>
<td>-0.17**</td>
<td>-0.27**</td>
<td>0.34**</td>
<td></td>
</tr>
<tr>
<td><strong>Helping / Friendly (CD)</strong></td>
<td>0.59**</td>
<td>0.41**</td>
<td>-0.12**</td>
<td>-0.17**</td>
<td>-0.24**</td>
<td>0.30**</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Understanding (CS)</strong></td>
<td>0.24**</td>
<td>-0.16**</td>
<td>-0.21**</td>
<td>-0.31**</td>
<td>0.22**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Student Responsibility / Freedom (SC)</strong></td>
<td>0.30**</td>
<td>0.22**</td>
<td>0.16**</td>
<td>0.26**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Uncertain (SO)</strong></td>
<td>0.54**</td>
<td>0.58**</td>
<td>0.19**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dissatisfied (OS)</strong></td>
<td>0.58**</td>
<td>0.19**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Admonishing (OD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.16**</td>
</tr>
<tr>
<td><strong>Strict (DO)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

** Significant at \( p<0.001 \)  
* Significant at \( p<0.01 \)  
n = 705.

**Figure 2.** Correlation of Understanding scale with other QTI scales showing the circumplex model.

The Understanding scale is highly correlated to its neighbouring scales, Student Responsibility/Freedom which has a correlation of 0.24 and 0.59 with the Helping/ Friendly scale. The correlation becomes lower with the next scale Uncertain which is negatively correlated with a score of -0.16. As the scales move further apart
correlations with Dissatisfied and Admonishing also become negative with scores of -0.21 and -0.31. The maximum negative correlation is with the opposite scale of Admonishing. Generally, the findings in this study support the circumplex model of QTI and hence validate it for use in Indian schools teaching science through the technology-supported classroom.

**Means and Standard Deviations on the QTI**

The data for the descriptive statistics concerning QTI were collected from 705 students in 15 classrooms and the values of means and standard deviations are given in Table 4. The highest mean value is 4.05 for the Leadership scale and the least value is 2.47 for the Admonishing scale. Figure 3 represents the means scores of the eight scales of the QTI in a graphical manner.

**Table 4**

**Means and Standard Deviations for the QTI**

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>No. of Items</th>
<th>Mean</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership (DC)</td>
<td>6</td>
<td>4.05</td>
<td>0.72</td>
</tr>
<tr>
<td>Helping / Friendly (CD)</td>
<td>6</td>
<td>3.63</td>
<td>0.80</td>
</tr>
<tr>
<td>Understanding (CS)</td>
<td>6</td>
<td>3.87</td>
<td>0.71</td>
</tr>
<tr>
<td>Student Responsibility /Fr</td>
<td>6</td>
<td>3.10</td>
<td>0.68</td>
</tr>
<tr>
<td>Uncertain (SO)</td>
<td>6</td>
<td>2.53</td>
<td>0.79</td>
</tr>
<tr>
<td>Dissatisfied (OS)</td>
<td>6</td>
<td>2.72</td>
<td>0.81</td>
</tr>
<tr>
<td>Admonishing (OD)</td>
<td>6</td>
<td>2.47</td>
<td>0.84</td>
</tr>
<tr>
<td>Strict (DO)</td>
<td>6</td>
<td>3.46</td>
<td>0.66</td>
</tr>
</tbody>
</table>

n = 705

**Figure 3.** Mean scores on the eight scales of the QTI.

The overall analysis of the above results shows that the students see their teachers as good leaders most of the time and have also rated their teachers in terms of exhibiting helpful and friendly nature, understanding and giving students freedom and responsibility in the classroom. In fact, the positive factors have been exhibited by the teachers quite often in the classroom. One interesting feature of the analysis is that students perceive their teachers to be strict which is acceptable in India as a teacher is in-charge of a class and gives direction to the students in various academic matters. Also, the negative aspects of the teacher-student interaction have been
rated quite low by the students as teachers seldom exhibit admonishing behaviour, are less dissatisfied and less uncertain. This shows that the technology-supported classroom environment may help in creating a healthy teacher-student interpersonal relationship and promote positive behaviour. Figure 4 represents a sector profile depicting student’s perception of the teacher-student interpersonal behaviour in the technology-supported science classroom in an Indian school which was developed by plotting the mean scores of the eight scales of the QTI (student questionnaire) in an excel worksheet. The sector profile reveals diagrammatically the degree to which students perceive each behavioural aspect exhibited by the teacher as measured through the QTI.

Figure 4. Sector profile diagram of students’ perception of their teachers’ interpersonal behaviour.

From Table 4 we can see that the standard deviation ranges from 0.66 for the Strict scale to 0.84 for the Admonishing scale. Since the values of the standard deviation are less than 1.00, it suggests that there is no major diversity in students’ perceptions.

Investigation of the QTI associations with student outcomes

As outlined in the objectives of the present study, it was investigated whether there are any associations between students’ perceptions of their teacher-student interactions with their attitude towards science, academic efficacy and academic achievement. In order to carry out these investigations, simple and multiple correlation analyses along with the calculation of regression coefficients were conducted between the eight interpersonal behaviour scales of the QTI and three student outcomes of attitude towards science, academic efficacy and academic achievement (the score obtained by the student in the annual examination at the end of the academic year).

Associations between the perceptions of teacher-student interactions measured using the QTI and the attitude of students towards science were explored using simple (r) and multiple correlations (R) followed by the regression analysis between the QTI scales and the Attitude Towards Science scale. The data thus obtained have been presented in Table 5. From the data, it can be deduced that out of the eight scales of QTI only six scales have a significant association with the Attitude Towards Science scale. These scales are Leadership, Helping/Friendly and Understanding which have a positive and significant correlation and Uncertain, Dissatisfied and Admonishing which have a negative and significant correlation. The scales with which there is no association are Student Responsibility/Freedom and Strict. The correlations for the significant scales of the QTI range from -0.02 for the Student Responsibility/ Freedom scale to 0.30 for the Leadership scale. The multiple correlation (R) between students’ perceptions as measured by the different scales of the QTI and the Attitude Towards Science Scale (as seen in Table 5) is 0.34 at the individual level of analysis, which is statistically significant (p<0.001). The R² value indicates that 12 percent of the variance in the students’ attitude towards science can be attributed to the students’ perception of teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the Attitude towards Science scale. Regression coefficient values (β) indicate (as given in Table 5.4) that two of the eight QTI scales uniquely account for a significant (p<0.001, p<0.01) amount of variance in attitude towards
science, these are Leadership with a value of 0.14 and Admonishing with a value of -0.16. The β value for Admonishing is negatively significant which implies that the admonishing behaviour of the teacher will have a negative influence on the attitude of the students towards science. On the other hand, a high score on Leadership suggests that teachers with good and effective leadership qualities in a class may also affect the development of a positive attitude amongst students in a technology-supported learning environment.

Simple (r) and multiple correlation (R) along with computation of the regression coefficient (β) were used to study the associations between the students’ perception of the teacher-student interactions as measured by the QTI and their academic efficacy. Table 5 illustrates the results of the statistical analysis. Computation of data shows that out of the eight scales of QTI only six scales have a significant association with the Academic Efficacy scale. These scales are Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom and Strict which have a positively significant correlation and Admonishing which has a negatively significant correlation. The scales with which there is no association are Uncertain and Dissatisfied. The correlations for the significant scales of QTI range from -0.08 for the Admonishing scale to 0.23 for the Leadership scale.

The multiple correlation (R) between students’ perceptions as measured by the different scales of QTI and the Academic Efficacy Scale (as seen in Table 5) is 0.26 at the individual level of analysis, which is statistically significant (p<0.001). The R² value indicates that six percent of the variance in students’ academic efficacy can be attributed to the students’ perception of their teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the Academic Efficacy scale. Regression coefficient values (β) indicate that two of the eight QTI scales uniquely account for a significant (p<0.01, p<0.05) amount of variance in academic efficacy, these are Leadership with a value of 0.19 and Student Responsibility/Freedom with a value of 0.11. The β value for these two scales is positively significant which implies that the leadership of the teacher and giving the students some freedom, opportunity and responsibility could go a long way in improving their academic efficacy.

Table 5
Associations between QTI Scales and three Learner Outcomes i.e. Attitude Towards Science, Academic Efficacy and Academic Achievement in terms of Simple Correlations (r), Multiple Correlation (R) and Standardised Regression Coefficient (β)

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Attitude Towards Science</th>
<th>Academic Efficacy</th>
<th>Academic Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>β</td>
<td>r</td>
</tr>
<tr>
<td>Leadership</td>
<td>0.30**</td>
<td>0.14**</td>
<td>0.23**</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>0.20**</td>
<td>0.01</td>
<td>0.18**</td>
</tr>
<tr>
<td>Understanding</td>
<td>0.25**</td>
<td>0.10</td>
<td>0.17**</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>-0.02</td>
<td>-0.05</td>
<td>0.16**</td>
</tr>
<tr>
<td>Uncertain</td>
<td>-0.20**</td>
<td>-0.04</td>
<td>-0.00</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>-0.20**</td>
<td>-0.02</td>
<td>-0.04</td>
</tr>
<tr>
<td>Admonishing</td>
<td>-0.30**</td>
<td>-0.16***</td>
<td>-0.08*</td>
</tr>
<tr>
<td>Strict</td>
<td>0.04</td>
<td>0.01</td>
<td>0.09*</td>
</tr>
<tr>
<td>Multiple Correlation (R)</td>
<td>R² = 0.34***</td>
<td>R² = 0.12</td>
<td>R² = 0.26***</td>
</tr>
</tbody>
</table>

*** Significant at p<0.001, ** Significant at p<0.01, * Significant at p<0.05
n = 705 students

Simple (r) and multiple correlation (R) along with computation of the regression coefficient (β) were used to study the associations between the students’ perceptions of the teacher-student interactions as measured by the QTI and their academic achievement. Table 5 illustrates the results of the statistical computation. Analysis of data shows that out of the eight scales of the QTI only seven scales have a significant association with the...
academic achievement scores. These scales are Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom, which have a positive correlation and Uncertain, Dissatisfied and Admonishing which have a negative correlation ($p<0.01$, $p<0.05$). The scale with which there is no association is Strict. The correlations for the significant scales of QTI range from -0.21 for the Uncertain and Dissatisfied scales to 0.23 for the Understanding scale.

The multiple correlation ($R$) between students’ perceptions as measured by the different scales of the QTI and the academic achievement scores (as seen in Table 5) is 0.33 at the individual level of analysis, which is statistically significant ($p<0.001$). The $R^2$ value indicates that 11 percent of the variance in students’ academic achievement can be attributed to the students’ perceptions of their teacher-student interactions. Standardized regression values were calculated to provide information about the unique contribution of each QTI scale to the academic achievement scores. Regression coefficient values ($\beta$) indicate (see Table 5) that four of the eight QTI scales uniquely account for a significant ($p<0.001$, $p<0.01$, $p<0.05$) amount of variance in academic achievement scores, these are Understanding with a value of 0.20, Student Responsibility/Freedom with a value of 0.14, Uncertain with a value of -0.21 and Admonishing with a value of -0.11. The $\beta$ value for the two scales is positively significant which implies that the proper understanding of the students needs and providing them with care along with giving them some freedom, opportunities and responsibility may help in increasing their academic achievement scores. On the other hand, uncertain and admonishing behaviour by the teacher may lead to a decrease in their academic achievement.

Gender Differences and Perceptions of Teacher-Student Interaction

In the present sample of 705 students taken from 15 classes, there were 379 (53.8%) male students and 326 (46.2%) female students who studied science in a technology-supported environment and interacted with teachers in their class. The means and standard deviations for the two groups were computed followed by a test of significance of difference between means ($t$-test for separate samples), to find out if there were any gender differences on the eight scales of the QTI. The data obtained statistically is presented in Table 6.

Table 6

<table>
<thead>
<tr>
<th>Scale</th>
<th>Gender</th>
<th>Mean</th>
<th>Mean Difference (M-F)</th>
<th>Standard Deviation</th>
<th>$t$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Males</td>
<td>4.02</td>
<td>-0.08</td>
<td>0.75</td>
<td>1.42</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>4.10</td>
<td></td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>Males</td>
<td>3.60</td>
<td>-0.10</td>
<td>0.81</td>
<td>1.35</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>3.70</td>
<td></td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Understanding</td>
<td>Males</td>
<td>3.80</td>
<td>-0.16</td>
<td>0.71</td>
<td>2.97</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>3.96</td>
<td></td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td>Student Responsibility</td>
<td>Males</td>
<td>3.10</td>
<td>-0.01</td>
<td>0.70</td>
<td>0.31</td>
</tr>
<tr>
<td>/Freedom</td>
<td>Females</td>
<td>3.11</td>
<td></td>
<td>0.67</td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td>Males</td>
<td>2.61</td>
<td>0.16</td>
<td>0.78</td>
<td>2.57</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>2.45</td>
<td></td>
<td>0.79</td>
<td></td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>Males</td>
<td>2.84</td>
<td>0.26</td>
<td>0.76</td>
<td>4.16</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>2.58</td>
<td></td>
<td>0.83</td>
<td></td>
</tr>
<tr>
<td>Admonishing</td>
<td>Males</td>
<td>2.55</td>
<td>0.18</td>
<td>0.83</td>
<td>2.84</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>2.37</td>
<td></td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>Strict</td>
<td>Males</td>
<td>3.45</td>
<td>-0.03</td>
<td>0.65</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>3.48</td>
<td></td>
<td>0.66</td>
<td></td>
</tr>
</tbody>
</table>

Males: n = 379; Females: n = 326
The data analysis reveals that there are no gender differences in students’ perceptions of their teacher-student interactions in a technology-supported science classroom environment. Thus, both male and female students perceived their teacher-student interactions in a similar manner, thus signifying homogeneity in the group. Figure 5 represents the mean scores of the male and female students on the eight scales of the QTI.

![Figure 5. Mean scores of male and female students on the eight scales of the QTI.](image)

CONCLUSION

A major contribution of the present study was establishing the reliability and validity of the Questionnaire on Teacher Interaction (QTI) which was used to assess students’ perceptions of their teacher interpersonal behaviour in a technology-supported secondary science classroom in an Indian school situation. Further investigation suggested that positive associations existed between students’ perception of their teacher-student interaction and their attitude towards science, academic efficacy and academic achievement in a technology-supported learning environment. Students’ perceived their teachers to exhibit leadership, helpful and friendly nature, sense of understanding and gave students fair amount of responsibility and freedom to express themselves in a technology-supported science classroom. They also felt that the teachers were less uncertain, dissatisfied and admonishing in their behaviour. However a reasonable number of students felt that the teachers were generally strict in the classroom. The study also demonstrated that there were no gender differences in students’ perceptions of their teacher-student interactions in a technology-supported science classroom environment. The findings of this research can be broadly applied for improving teachers’ interpersonal behaviour as it provides clues through students’ perceptions as to what kind of behaviour students like teachers to exhibit in the classroom which may lead to improvement in the day-to-day classroom learning environment and make learning more interactive and meaningful.

REFERENCES


MATHEMATICS CONTENT KNOWLEDGE OF PRE-SERVICE PRIMARY TEACHERS: DEVELOPING CONFIDENCE AND COMPETENCE

Brenda Hamlett
Curtin University
Australia

ABSTRACT

In order to become effective teachers of mathematics in primary schools, pre-service teachers not only need to be competent in the relevant curriculum content, but also able to understand and explain the underlying concepts. Unfortunately, reports from Australia and overseas indicate that many of them enter university education degree courses with low levels of skills and confidence in mathematics. This paper examines the extent to which first year pre-service teachers enrolled in BEd courses in Primary and Early Childhood Education can be considered as mathematically literate in terms of the content of the Western Australian primary mathematics curriculum, and describes an approach to addressing any shortcomings as part of a first year core unit called Becoming Multiliterate. On entry to the unit, pre-service teachers complete a diagnostic assessment task based on relevant outcomes of the Western Australian Outcomes and Standards Framework: Mathematics, and also indicate how confident they feel about their answers. When giving back results, an emphasis is placed on identifying individual strengths and weaknesses, so that current skills are acknowledged, and areas for improvement are targeted. Students complete activities designed to engage and motivate them and ensure that both confidence and competence are considered in skill development. This reflects a CRC approach – Comment what is being done well, Recommend strategies for improvement and Commend subsequent achievements. At the end of the unit, results in the exit assessment and comments in unit evaluations indicate that students not only display higher skill levels but feel more positive about mathematics.

BACKGROUND

One version of the job description for a teacher includes the following:

- Teachers must know their stuff
- They must know the students they intend to stuff
- Above all, they must stuff them artistically

(source unknown, cited in Sobel & Maletsky, 1975, p 2)

Shulman (1986) defined three broad areas of teacher knowledge:

- Subject content knowledge (SCK)
- Pedagogical content knowledge (PCK)
- Curricular knowledge

These and other models emphasise the importance of the teacher being familiar with, and having a deep understanding of, the content of the material they have to teach.

Good teaching of mathematics has been given increased attention in recent years because of widespread international concerns about numeracy levels in education and the wider community. The 2003 Program for International Assessment (PISA) conducted by the Organisation for Economic Cooperation and Development focussed on the mathematics ability of fifteen year olds in and the results created headlines in many countries – not always for positive reasons. There were similar reactions to the Trends in International Mathematics and Science Study (TIMSS) results which looked at fourth and eighth grade students in 49 countries in 2003 and more than 60 countries in 2007. Just as Sputnik triggered a focus on mathematics and science education in the USA in the late 1950s and 1960s, results from programs such as PISA and TIMSS have influenced politicians and educators to look closely the content and pedagogy of their mathematics curricula. In Australia, nationally defined standards have been developed, reviewed and refined and numeracy has become a political football with parents blaming schools, schools blaming state governments, state governments blaming the federal government and everyone expecting teachers to fix the problems.

A number of issues have been investigated when addressing concerns about primary teacher numeracy. A number of these have fuelled the debate about the definition of numeracy in this context: is it just competence in handling numbers, or the ability to apply learned skills to practical situations, or do teachers require a different kind or level of numeracy to the general population and the children they teach? The work by Ball and her associates at the National Center for Research on Teacher Learning (Ball, 1988a, 1988b, 1988c; Ball & Wilson, 1990) looked at both pre-service and in-service development of teacher SCK and suggested strategies for
improvement. The oft-quoted work by Liping Ma (1999), which compared the mathematical knowledge of teachers in China and the USA, emphasised the need for teachers to have “deep understanding”. For example, they must know how numbers work and not just how to manipulate them if they are to ensure their students develop understanding as well as skills.

In the UK the Subject Knowledge in Mathematics (SKIMA) group has looked closely at pre-service teacher knowledge of mathematics at two institutions and identified clear weaknesses in understanding, as well as a link between low levels of subject knowledge and poor planning and teaching in a classroom situation. The implications of their findings, in the light of the requirement for initial teacher training to include an audit of mathematical subject knowledge, included consideration of whether the audit is itself creating anxiety which affects performance, as well as how to solve the problem of fitting specific teaching of mathematics content into an already full pre-service curriculum (Goulding, Rowland & Barber, 2002).

A number of intervention strategies have been investigated. Most involve some kind of skills audit to identify areas of weakness together with remediation or support programs intended to enable pre-service teachers to improve their performance. Self directed approaches provide resources but leave it up to students to take advantage of these, so the usefulness depends on the level of commitment, which in turn is often related to the consequences of continued poor performance (Sanders & Morris, 2000). Other institutions have attempted to include specific content teaching in mathematics methods units with mixed success, especially if the number of units remains the same, as developing SCK may be at the expense of PCK (Buck, 2004). A third type of approach uses specific content units, which may be in addition to the normal program and hence require students to overload (Morris, 2001).

All of these approaches are deficit models and can have a negative impact on how pre-service teachers feel about mathematics. Frank (1990) identified a number of prevailing myths about mathematics such as, “some people have a math mind and some don’t”, and “math requires a good memory”. Being told that their performance is below standard can reinforce these for some students. For some students mathematics is associated with intense emotions and their response to perceived criticism can be feelings of shame. This can be a positive motivational force, but for many students it can lead to behaviours such as avoidance, disguise, diversion and self-denigration (Bibby, 2002).

Sanders and Morris (2000) noted three types of responses from students who had been diagnosed as having weaknesses in their mathematical subject knowledge.

- ‘Ostriches’ hoped that if they ignored the problem long enough it would just go away
- ‘Mananas’ realised that they had to do something and resolved to work on improvement, but not just at the moment.
- ‘Nettle graspers’ faced their difficulties and immediately seized opportunities to work on skill development.

It is likely that the students in this study comprise a mix of all three types.

The CRC approach

Based on a technique used by Toastmasters Australia for giving constructive feedback to public speakers and further developed for use in performance appraisal, the CRC approach addresses some of the problems caused by a deficit model. As used in this study it comprises three stages:

- Commend the students for what they already know
- Recommend areas and strategies for improvement
- Commend students for subsequent gains in knowledge, understanding and, hopefully, confidence.

Multiliteracy

The usual definition of multiliteracy relates to the ability to apply literacy skills to different media, especially those involving digital technologies (Tyner, 1998). A broader definition considers discourses in other fields of study to be part of the development of multiliteracy, for example the interaction of scientific inquiry with literacy (Hanauer, 2006). Mathematical literacy is used in a number of areas as an alternative to the term ‘numeracy’, and the need for computer literacy is well established.

With the unit developed as part of this study, being multiliterate has been interpreted in the wide sense of being able to demonstrate skills equivalent to a lower secondary level in four areas:

- Information and communications technology (ICT)
- Mathematics
- Science
- Writing
Implicit in all four is the need for students to be literate in reading a variety of texts and media, although this is not addressed explicitly, nor are oral literacy skills.

**BECOMING MULTILITERATE UNIT**

The introduction of new Primary and Early Childhood BEd degrees in 2005, which included a unit entitled ‘Becoming Multiliterate’, provided an opportunity to put the CRC approach into practice. Throughout its development and implementation, the staff have adopted a positive supportive approach to students and apply simple strategies such as calling the audit tests ‘entry assessment tasks’, providing checklists which highlight the skills which have already been demonstrated, and not requiring students to be re-assessed in areas where they have met the benchmarks. A range of resources is available to enable students to develop and practise their areas of weakness and there are multiple opportunities to achieve the required standards in all areas.

The unit is conducted during the first semester of the degree course and students are given detailed information during orientation so they are prepared for the assessment tasks in week one. Checklists of the required skills are provided and the program for the first session explained. As this consists of three separate diagnostic tasks of 55 minutes each in writing, mathematics and science, this can be a stressful introduction to university study. An emphasis is placed on the use of the results of the assessments in identifying strengths and weaknesses and the marks do not contribute to their final grade for the unit, unless they happen to meet the benchmark straightaway. Once the tasks are marked, checklists are used to sign off the outcomes that have been achieved and hence identify the areas where skill development is needed.

Following the entry tasks, two weeks are spent on ICT tasks while the staff complete the marking. These tasks include the use of the online university library services, appropriate internet research and use of web-based materials and using Microsoft Word to create documents which include graphics, tables and other formatting options. During the second ICT session, individual students meet with staff to be given their results and their allocation to the various modules in the rest of the semester.

Each of the modules in mathematics, science and writing is taught by staff members with expertise in that learning area and who also teach the methods units later in the degree. The students are allocated to a rotation of three modules, each lasting three weeks with three hours of contact each week. At the start of week one of each rotation, staff discuss the entry tasks and students can read their papers and identify exactly what they need to do to improve their performance. In the final hour of week three, students sit an exit assessment that has exactly the same format as the entry task and in which they only have to answer the questions they did not get right the first time.

Classes are held in computer laboratories, although science classes move to science classrooms for practical work. This enables the class size to be kept to a maximum of 22 students to match the number of computers in the room. All students have computer access at home either with their own computers or through the university laptop program so they can use the online resources outside class contact times. Teaching includes one-on-one discussion between the student and tutor, individual work on the computer or worksheets, small group work including peer assisted learning and peer tutoring, and some whole class instruction.

**Mathematics module**

Twenty specific outcomes have been defined for the mathematics module and these are based on the year 9 benchmarks for secondary school students in Western Australia. The assessment tasks link directly to the outcomes, so students know what each question is about and what they need to work on if they do not get a particular question correct.

A score of 75% overall is sufficient to meet the requirements of the module but students who score less than this will not have to repeat any question in which they score 75% of the available marks. So for example, a student may only get 50% overall in the task but in a particular question a score of four out of five is sufficient to have that question signed off. This has a positive effect on morale and means that study time can focus on areas that need most attention. Another positive is that in the next task the student will have fewer questions to answer and can spend more time thinking about each one.

Students are provided with workbooks which list the outcomes and identify specific website activities and written worksheets which have information and exercises on each topic. A commercial website designed for school students is used and this has the capability of allowing the teacher to design a customised course from the range of exercises available. In addition, staff conduct a number of practical activities using manipulatives and model strategies used in primary classrooms to teach similar content. This is made explicit to students so they are learning mathematical teaching methods at the same time as content.
STUDENT PERFORMANCE

Entry task results are disappointingly weak, considering these students have met the requirements for university entry. Less than five students each year achieve the benchmarks in all three tasks at their first attempt. Tables 1 and 2 summarise the overall performances for 2006 and 2007. The percentage figures are based on the number of students enrolled in the unit during that semester.

<table>
<thead>
<tr>
<th>Year</th>
<th>Science</th>
<th>Mathematics</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>31 (9%)</td>
<td>38 (11%)</td>
<td>45 (13%)</td>
</tr>
<tr>
<td>2007</td>
<td>28 (8%)</td>
<td>19 (6%)</td>
<td>17 (5%)</td>
</tr>
</tbody>
</table>

Table 1: Number of Students who Achieved Benchmarks at First Attempt: 2006 and 2007

<table>
<thead>
<tr>
<th>Year</th>
<th>Science</th>
<th>Mathematics</th>
<th>Writing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>52.4</td>
<td>50.9</td>
<td>62.7</td>
</tr>
<tr>
<td>2007</td>
<td>50.9</td>
<td>50.6</td>
<td>74.3</td>
</tr>
</tbody>
</table>

Table 2: Mean Percentage Scores on Entry Tasks: 2006 and 2007

The three sections of the writing task are scored separately. The Word Usage task involves selecting the appropriate word to fill a space in a sentence where choices are from easily confused words such as accept and except, lose and lose, and to, two and too.

Given that much of the content being assessed is taught in primary schools, these poor results are cause for concern.

However, the performances on exit are significantly improved. For the purposes of this paper, only the mathematics results are considered but similar changes are achieved in the other two modules. The mean score on exit in 2006 was 70.4 and in 2007 was 76.2. This still meant that a number of students had not met the 75% benchmark and they were required to repeat the unit the following year. University policy allows a student to attempt and fail a unit three times before they are excluded from the course and so far this has happened for four students. A number of others accept that teaching may not be the career for them and choose to withdraw so the unit is acting as a critical filter in monitoring professional standards.

Mathematics performance by question

Table 3 summarises student performance against each mathematics outcome in the entry and exit assessments in 2006 and 2007. Although questions have different weightings according to the anticipated difficulty and expected time taken to complete them successfully, scores have been scaled to allow comparison among questions.

The tabulated data is based only on those students who sat both the entry and the exit assessments. Results for students who met the benchmark in the entry task have been excluded. All differences between entry and exit means of question scores are significant ($p < 0.001$).
<table>
<thead>
<tr>
<th>Question / Outcome</th>
<th>2006 Mean Scores (/4)</th>
<th>2007 Mean Scores (/4)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Entry</td>
<td>Exit</td>
</tr>
<tr>
<td>1 N1 Write large and small numbers in figures and words.</td>
<td>3.4</td>
<td>3.5</td>
</tr>
<tr>
<td>2 N2 Put fractions and decimals in increasing or decreasing order.</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>3 N3 Locate fractions and decimals on number lines and scales.</td>
<td>3.1</td>
<td>3.0</td>
</tr>
<tr>
<td>4 N4 Explain which will be the correct operations to use when presented with word problems.</td>
<td>2.4</td>
<td>3.0</td>
</tr>
<tr>
<td>5 N5 Add, subtract, multiply and divide whole numbers and decimals using mental arithmetic and pen and paper methods.</td>
<td>2.0</td>
<td>3.0</td>
</tr>
<tr>
<td>6 N6 Perform calculations involving money using the four operations.</td>
<td>3.4</td>
<td>3.6</td>
</tr>
<tr>
<td>7 M2 Convert among units within the metric system eg cm to m, kg to g.</td>
<td>2.8</td>
<td>3.3</td>
</tr>
<tr>
<td>8 M3 Determine the perimeter, area or volume of shapes which can be decomposed into squares or cubes.</td>
<td>1.8</td>
<td>2.5</td>
</tr>
<tr>
<td>9 M4 Find lengths, areas and volumes of shapes which have been enlarged or reduced by a simple scale factor eg on maps or scale models.</td>
<td>1.6</td>
<td>2.4</td>
</tr>
<tr>
<td>10 M5 Provide estimates of the size or mass of objects within the room.</td>
<td>1.3</td>
<td>1.8</td>
</tr>
<tr>
<td>11 C1 Estimate the probability of simple events eg a particular outcome when rolling a die.</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>12 C2 Summarise a data set eg finds mean, maximum, range, relative frequency of a given value.</td>
<td>2.4</td>
<td>3.1</td>
</tr>
<tr>
<td>13 S1 Draw representations of simple three dimensional shapes eg plan and elevation, perspective view.</td>
<td>2.6</td>
<td>3.2</td>
</tr>
<tr>
<td>14 M1 Measure the length of line segments S2 Interpret maps in terms of the direction and distance between points.</td>
<td>2.2</td>
<td>2.9</td>
</tr>
<tr>
<td>15 S3 Identify the symmetry properties of figures in two and three dimensions.</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>16 S4 Sketch the image of 2D shapes after reflection or rotation.</td>
<td>3.1</td>
<td>3.3</td>
</tr>
<tr>
<td>17 S5 Identify properties of shapes such as parallel and perpendicular lines, congruent and similar figures, acute and obtuse angles.</td>
<td>1.8</td>
<td>2.7</td>
</tr>
<tr>
<td>18 A1 Write a simple story explaining the changes in a quantity represented on a graph eg mood changes during the day, traffic flow data.</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>19 A2 Continue simple sequences of numbers or shapes, explaining how they obtained their answer.</td>
<td>2.0</td>
<td>3.1</td>
</tr>
<tr>
<td>20 A3 Solve “find the missing number” problems.</td>
<td>2.6</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Student confidence

When completing the entry task students are also asked to indicate the level of confidence they have that they have answered each question correctly. This is via a Likert scale alongside each question where scores are allocated as follows:

1  Not at all confident
2  A little confident
3  Reasonably confident
4  Very confident

As one of the purposes of the unit design is to address issues of confidence it is important that the assessment process does not have a negative effect on student attitudes to mathematics and its teaching. To determine what effect, if any, the unit had on confidence levels, students enrolled in the Primary BEd course were surveyed at the start of the following semester as part of their first mathematics methods unit. For each question from the entry assessment they were asked to indicate their current level of confidence in being able to answer the question correctly and also how confident they felt about being able to teach the content associated with the question to primary school children. Scores were combined for each question to produce percentage scores for performance confidence both before and after the module, and for teaching confidence.

Table 4
Mean Percentage Confidence Levels: 2006 and 2007

<table>
<thead>
<tr>
<th></th>
<th>Performance confidence</th>
<th>Teaching confidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On entry to the unit</td>
<td>After completing the unit</td>
</tr>
<tr>
<td>2006</td>
<td>73.8</td>
<td>85.1</td>
</tr>
<tr>
<td>2007</td>
<td>67.5</td>
<td>79.2</td>
</tr>
</tbody>
</table>

Improvements in performance confidence are significant (p<0.001) for both years. Of note is that while performance confidence has increased, confidence in ability to teach the same content is at a similar level to entry scores. Further investigation into teaching confidence after the mathematics methods units have been completed would be worthwhile.

Effectiveness of the Unit

While data on the results in science and writing is not presented here, similar trends are evident. Students feel more confident about their knowledge following the unit and with more justification as their scores have improved.

The university requires unit evaluations to be completed each semester and the results of these support the conclusions discussed in this paper. In 2006 86% of students agreed that they were satisfied with the unit (90% in 2007) and 87% agreed that the unit had enhanced their skills and knowledge in the subjects (90% in 2007). In addition, 86% agreed that the activities had supported their learning (92% in 2007).

In support of the work of the tutors in implementing a CRC approach aimed at developing both skills and confidence, the following comments taken from the feedback forms are typical:

- It was fantastic that the tutor never made you feel stupid, regardless of how basic the question was. The tutor allowed us to work at our own pace and get on with the work ourselves but was there if we needed help.
- I believe that the thing that best helped my learning was that the tutor wanted to help.

CONCLUSION

Pre-service teachers who are the focus of this study have low levels of mathematical literacy across most areas of the primary school mathematics curriculum. This is consistent with similar studies in the UK and USA. An intervention unit based on specific learning outcomes and taking a Commend, Recommend and Commend (CRC) approach has proved effective, at least in the short term, in improving mathematics skill levels and confidence. Similar changes have been achieved in the associated modules in the unit that focus on writing and scientific literacy. Further research into the longer term effectiveness of the unit is being conducted as students progress through the degree program.
REFERENCES


NOTE-TAKING REVISITED: THE EFFECT OF NOTE-TAKING STRATEGIES ON STUDENTS' COMPREHENSION IN PSYCHOLOGY CLASSES AT JAPANESE UNIVERSITIES

Sonomi Hirata
Hakuoh University
Japan
Makoto Ishikawa
Joetsu University of Education
Japan

ABSTRACT

The purpose of this study is to explore the effect of note-taking strategies on university students' comprehension in class. A self-description questionnaire asking for students' learning goals and strategies in class was administered to 240 freshmen and sophomores at two universities in the Tokyo metropolitan area. True or false questions as a comprehension examination were also administered, after a story shown in slides about observer-expectancy effect generally known as "Clever Hans", a science teaching material, was shown. An analysis of the self-description questionnaire revealed that students' motivation for note-taking was classified as follows; in order to pass an examination, for future use, better understanding, review, and intellectual curiosity. While students' note-taking strategies were classified as; color the highlights, easy to read, beautiful writing as a word processor document, spelling carefully, underlining, and adding explanatory notes. These data were analyzed using 95 percent confidence interval and Chi-square test. The results showed that students' higher score on the comprehension examination is relevant to their motivation for note-taking in class, like intellectual curiosity. Concerning the strategy on note-taking, it was shown that learners who prefer such methods to promote clear understanding tend to exhibit higher achievement, such as underlining and adding explanatory notes. These findings lead to the conclusion that students' learning goals and note-taking strategies are relevant to students' comprehension in class. It is useful for teachers to analyze students' motivation and strategies for note-taking, as this information provides a useful clue to guide the students' towards more effective learning in higher education.

INTRODUCTION

The ratio of Japanese high school graduates who go on to junior college or university has already risen to 50 percent, which means that the higher education system in Japan has arrived at the stage of “universal access”. On this stage, it is predicted that students' academic levels and learning approaches will become more diversified (Trow, 1976). According to the Daily Yomiuri, an online newspaper (2005), this conclusion was supported by a large scale survey administered to about 28,000 full-time teachers including professors, assistant professors and lecturers at universities and junior colleges by the Japan Universities Association for Computer Education, a non-profit organization under the Japanese MEXT, Ministry of Education, Science, Sports and Culture. The survey reported that more than 60 percent of teachers at private universities and junior colleges across the nation answered that their students' basic academic abilities are insufficient. The result was more than 20 percentage points higher than a similar survey conducted six years ago.

Recently, given these findings, special courses for freshmen to learn how to study at university have been started at most universities and colleges nationwide, such as "freshman seminar", and "study skills". Williams (1996) states that, “Study skills are explicit techniques to help learners actively process information. These consist of such activities as note-taking, outlining, underlining, and the identification and noting of patterns in the new material”. Kiewra (1985) reported that historically investigators have divided note-taking into its process and product functions. The former found that students who take lecture notes generally achieve more than students who simply listen during the lecture, while the latter concluded that students who review their notes generally achieve more than students who do not. Concerning the Japanese context, one may say that the main question in note-taking is the product function rather than process function because most Japanese students are very keen to take notes in class. Indeed, some students try not to miss anything and nervously take pictures of a slideshow or blackboard with a digital camera.

In order to develop a more effective course for university freshmen at the stage of universal access, it is important to investigate the various factors that contribute to the actual conditions of students’ study skills such as note-taking. The purpose of the present study is, therefore, to explore the effect of note-taking strategies on students' comprehension in class at Japanese universities. This paper deals with both students' motivation and the element of note-taking strategy, and its effect.
METHODS AND PROCEDURE

Sample
The sample for the study consisted of 240 freshmen and sophomores at two universities in the Tokyo metropolitan area. 152 students attended an environmental psychology class at a science and technological university and 88 students attended an educational psychology class at a university of education.

Instrument
A self-description questionnaire asking one’s own methods for learning and note-taking strategies in class was administered to all the students. Nine true or false questions as shown below (Table 1) as a comprehension examination was also administered to all students, after a story slideshow (Fig.1) about observer-expectancy effect generally known as "Clever Hans", a science teaching material, were shown.

Table 1
Comprehension examination: nine true or false questions concerning Clever Hans

1. [T/F] Someone who does not know about Hans shall set a calculation question to Hans. (=-0.458)
2. [T/F] Instead of a man, computer shall set a calculation question to Hans. (=5.588*)
3. [T/F] The child who is very proud of Hans shall set a calculation question to Hans. (=4.369*)
4. [T/F] The horse owner keeping a poker face shall set a calculation question to Hans. (=0.601)
5. [T/F] The horse owner performing various expressions shall set a calculation question to Hans. (=0.428)
6. [T/F] To investigate the effect of a new medicine, the doctor who developed it by himself shall administer it to the patient. (~-0.446)
7. [T/F] To investigate the effect of a new medicine, developers shall ask the experiment to a tester after they explain the effect of it to him/her. (=3.288*)
8. [T/F] To investigate the effect of a new medicine, the doctor shall administer it to the patient who knows the effect of it. (=4.691*)
9. [T/F] To investigate the effect of a new medicine, the doctor who does not know its effect shall administer it to the patient. (=8.904*)

(*=items of the higher discrimination power group)

HansOskar Pfungst, psychologist, found that Hans was answered by tapping his hoof seven times. Without the unconscious message from the audience, responding to subtle physical cues from the audience! Hans hardly could solve any problems.

*Figure 1. Story slides of Clever Hans (22 slides in all).*
RESULTS AND DISCUSSION

Data arrangement

Motivation for note-taking: The same motivation for note-taking which five or more students answered in common are 21 kinds, and here we chose 10 kinds of intention that 10% or more students answered. That is, for example, to pass an examination, for future use, better understanding, review, and intellectual curiosity.

Note-taking strategies: The same strategy for note-taking which five or more students answered in common are 31 kinds, and here we chose 13 kinds of responses that 10% or more students answered. For example, color the highlights, easy to read, beautiful as a word processor document, spelling carefully, underlining, and adding explanatory notes.

Comprehension examination: Nine questions concerning the story of Clever Hans (see Table 1) as a comprehension examination were analyzed via Item Response Theory (IRT) based on the 2 parameter logistic model (2PL model). Items of the higher discrimination power group were chosen for the detailed analysis.

ANALYSIS AND RESULTS

Motivation of note-taking and students' comprehension

The results were analyzed using 95 percent confidence interval. The students were classified according to the motivation for note-taking, and each group’s mean of the total score of comprehension examination was compared in 95 percent confidence interval. Statistically significant differences were found in that the students who scored higher on the examination reported their motivation for note-taking was intellectual curiosity. By contrast, students with lower examination scores answered that the purpose of note-taking was to review their lessons (Fig.2). Furthermore, to compare the effects of the motivation of note-taking on students’ comprehension, the number of students of each group were counted (Table 2). A significant Chi-square difference was found between the two motivations: review and intellectual curiosity ($\chi^2 = 6.630, p<.05$). The results here agree with those obtained in Fig.2 below.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Chi square of Motivation of Note-taking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motivation /Comprehension Examination</td>
<td>review</td>
</tr>
<tr>
<td>high score group</td>
<td>16</td>
</tr>
<tr>
<td>low score group</td>
<td>10</td>
</tr>
<tr>
<td>total</td>
<td>26</td>
</tr>
</tbody>
</table>

$x^2(1) = 6.630, \ *p<.05,$

Note-taking strategies and students' comprehension

The following results were obtained: the students in the high score group chose the strategy for note-taking such as underlining and adding explanatory notes. Students whose examination score was low, however, preferred the notebook easy to read and beautiful as a word processor document, and to spell carefully (Figure 2). Concerning the number of students, Chi-square was not significant between five strategies ($x^2(4) = 4.797, \text{n.s.}$).
CONCLUSION

As technology advances, the style of learning in lecture-type classrooms has become more diversified in colleges and universities. It is already popular worldwide to use presentation software and its files as handouts for students in class. Note-taking might sound like a study skill of a past generation. Now it may be recalled here that the present study is entitled "note-taking revisited". Most of us realize that note-taking is traditional and the most essential study skill for learning. What is not so clearly understood, however, is the effect of its strategy and the motivation behind it.

Analysis of the present self-description questionnaire revealed that each individual student’s note-taking was quite various and unique in not only strategy but also motivation. The results showed that a student’s higher score on the comprehension examination is relevant to their motivation for note-taking, like intellectual curiosity. Concerning the strategy on note-taking, it was shown that the learners who prefer the methods to promote clear understanding tend to receive higher achievement, such as underlining and adding explanatory notes.

As Trow’s (1976) foresaw, on attaining the stage of universal access, students’ academic levels and learning approaches also became more diversified in Japanese higher education. Some students enter university without clear goal orientation. The importance for learning motivation will not change even if the study style changes with new technology. Furthermore, it becomes more important to guide freshmen not only in the practical but also the academic meaning of each subject, the required study skills for each subject, and especially to develop real interest in each study area. The findings here lead to the conclusion that students’ learning goals and note-taking strategies are relevant to students' comprehension in class. It is useful therefore for teachers to analyze students’ motivation and strategies for note-taking in seminars for freshmen, as this information will be a good clue in order to develop more essential and effective learning for students in higher education.

REFERENCES

THE LABORATORY IN SCIENCE EDUCATION: FROM THEORY TO PRACTICE

Avi Hofstein
The Weizmann Institute of Science
Israel
(Invited keynote address)

INTRODUCTION: WHAT RESEARCH SAYS ABOUT LEARNING IN AND FROM SCIENCE LABORATORIES

Laboratory activities have long had a distinctive and central role in the science curriculum and science educators have suggested that many benefits accrue from engaging students in science laboratory activities (Hofstein & Lunetta 1982; Tobin 1990; Lunetta 1998; Lazarowitz & Tamir, 1994; Hofstein & Lunetta, 2004). More specifically, they suggested that, when properly developed, designed, and structured laboratory-centered science curricula have the potential to enhance students’ meaningful learning, conceptual understanding, and their understanding of the nature of science. Also, Inquiry-type experiences in the science laboratory are especially effective if conducted in the context of, and integrated with, the concept being taught.

Many research studies have been conducted to investigate the educational effectiveness of laboratory work in science education in facilitating the attainment of the cognitive, affective, and practical goals. These studies were critically and extensively reviewed in the literature (e.g., Blosser 1983, Hofstein & Lunetta 1982, Bryce & Robertson 1985, Tobin, 1990; Hodson, 1993, Lazarowitz & Tamir 1994, Hofstein & Lunetta, 2004; Lunetta, Hofstein, & Clough, 2007). From these reviews it is fairly clear that in general, although the science laboratory has been given a distinctive role in science education, research has failed to show simplistic relationships between experiences in the laboratory and student learning. Hodson (1993) has criticized laboratory work and claimed that it is unproductive, and confusing, since it is very often used unthinkingly without any clearly thought-out learning goals, and called for more focus on what students are actually doing in the laboratory. He also suggested that the laboratory should be used in order to explore phenomena, solve scientific problems, and pursue scientific interest. Tobin (1990) suggested that meaningful learning is possible in the laboratory if students are given opportunities to manipulate equipment and materials so as to be able to construct their knowledge of phenomena and related scientific concepts. In addition, it was suggested that, if designed properly the science laboratory has the potential to play an important role in attaining cognitive skills and metacognitive skills (Baird, 1990). Metacognition involves elaboration and application of one’s learning, which can result in enhanced understanding. In the laboratory we provide the students with opportunities to take control of their own learning in the search for understanding. In this process it is vital to provide opportunities that encourage learners to ask questions, suggest hypothesis, and design investigations ‘minds-on as well as hands-on’. Baird (1990) suggested that this could only be accomplished if the laboratory learning environment will undergo a radical shift from teacher-centered learning to purposeful inquiry that is significantly more student-centered. It should be noted that inquiry refers to diverse ways in which scientists study the natural world, propose ideas, and explain and justify assertions based upon evidence derived from scientific work. The laboratory is important in the current era in which inquiry has re-emerged as a central style advocated for science teaching and learning (NRC, 1996; Bybee, 2000). A constructivist model currently serves as a theoretical organizer for many science educators who are trying to understand cognition in science (Lunetta, 1998), i.e., learners construct their ideas and understanding on the basis of series of personal experiences. Moreover, there is a growing sense that learning is contextualized and that learners construct knowledge by solving genuine and meaningful problems (Brown, Collins, & Duguid, 1989; Roth, 1994) Experiences in the school laboratory can provide such opportunities for students if the expectations of the teacher enable them to engage intellectually with meaningful investigative experiences upon which they can construct scientific concepts within a community of learners in their classroom (Roth & Roychoudhury, 1993).

However as Tobin (1990) claimed, in general, research has failed to show evidence that such opportunities really exist. What are the reasons for the lack of evidence that learning is taking place in the science laboratory? In other words, “If it is so good why is it so bad”? 
WHERE ARE WE AT THE BEGINNING OF THE 21ST CENTURY? SOME ISSUES AND PROBLEMS REGARDING LEARNING IN AND FROM SCIENCE LABORATORIES

In 1982, Hofstein & Lunetta, published a frequently cited review on the laboratory work. In summarizing the review they wrote:

“Researchers must examine the goals of science teaching and learning with care to identify optimal activities and experiences from all modes of instruction that will best facilitate these goals. ... There is a real need to pursue vigorously research on learning through laboratory activities to capitalize on the uniqueness of this mode of instruction for certain learning outcomes” (p. 213.)

While there is little doubt that substantial progress has been made in identifying teacher behaviours and other variables that can promote meaningful learning consistent with contemporary standards, these it is suggested comments are also valid at this writing 20 years later Hofstein & Lunetta, 2004; Lunetta, Hofstein, & Clugh, 2007). That said, the assumption that laboratory experiences help students understand materials, phenomena, concepts, models, and relationships, almost independent of the nature of the laboratory experience, continues to be widespread in spite of sparse data from carefully designed and conducted studies. A more recent assertion is that laboratory experiences can help students develop ideas about the nature of a scientific community and the nature of science. During the past 25 years since Lunetta and Hofstein (1982) published their review, substantial new knowledge has been developed about cognitive development, development of high order learning skills, learning and teaching styles, the classroom laboratory learning environment, and the nature of science. This new knowledge has fueled many ideas about ways the sciences should be taught to promote understanding. In addition, significant changes in computer technologies offer substantive new tools and resources for empowering teaching and learning science that can complement experiences in the school laboratory. Moreover, more sensitive social science research methodologies have been developed that enable science education researchers to examine more carefully the ideas of students and their teachers and the effects of a variety of learning environment variables on the development of students’ concepts, skills, motivation, interests, perceptions, and attitudes.

At the beginning of the 21st century, when many are again seeking reform in science education, the knowledge that has been developed about learning based upon careful scholarship should be incorporated in that reform. The “less is more” slogan in Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993, p.320) has been articulated to guide curriculum development and teaching consistent with the contemporary reform. The intended message is that formal teaching results in greater understanding when students study a limited number of topics, in depth and with care, rather than a large numbers of topics much more superficially, as is the practice in many science classrooms. Well-designed science laboratory activities focused on inquiry skills can provide learning opportunities that help students develop concepts, frameworks of concepts, and high-order learning skills. In other words to help students learn to investigate, to hypothesise and plan experiments that will help to accept or reject a certain scientific hypothesis, to construct scientific assertions, and to justify those assertions in a classroom community of peer investigators in contact with a more expert scientific community. To attain such important but demanding goals, the education system must provide time and opportunities for teachers to interact with their students and also time for students to perform and reflect on complex, investigative and inquiry-type skills both in the science classroom as-well-as in the science laboratory.

Clearly, serious discrepancies exist between what is recommended for teaching in the laboratory-classroom and what is actually occurring in many classrooms. Very often we find that there is mismatch between teachers’ goals and learning goals and what students think is the purpose of practical work and what teachers think what the goals are. Researchers need to examine and understand why large numbers of “good teachers” have not been using authentic and practical assessment on a regular basis. Such understanding should then shape research on classroom practice, the development of assessment techniques, teacher professional development, and further research studies. No doubt, the issues are complex, but explanations may lie in differences in the perceptions of teachers and researchers. For example, teachers may perceive they do not have the time or skill required to implement such assessment methodologies successfully. Reluctance may also originate in the beliefs teachers hold about what students should be learning in laboratory experiences, how students learn, what they need to do to achieve important learning outcomes, and what they need to perform successfully on external-type practical examinations. Building on relevant scholarship, future research in science education should produce
information that informs the development of strategies, protocols, and resources for teaching and for the professional development of teachers. Questions to be addressed include how to assess students’ learning efficiently and effectively when they are engaging in inquiry and practical work, how to engage students with different skills and knowledge in practical experiences that result in meaningful learning, and how to promote a more effective laboratory learning environment.

During the past twenty years, we have expanded our knowledge about circumstances that inhibit and promote conceptual learning in science classrooms in general and in the science laboratory in particular. Factors that continue to inhibit learning in the school science laboratory include:

- Many of the activities outlined for students in laboratory guides continue to offer “cook-book” lists of tasks for students to follow ritualistically. They do not engage students in thinking about the larger purposes of their investigation and of the sequence of tasks they need to pursue to achieve those ends;
- Assessment of students’ practical knowledge and abilities and of the purposes of laboratory inquiry tends to be seriously neglected; even by high stakes tests that purport to assess science standards. Thus many students do not perceive laboratory experiences to be particularly important in their learning;
- Teachers and school administrators are often not well informed about what is suggested as best professional practice and they do not understand the rationale behind such suggestions. Thus, there is a high potential for mismatch between a teacher’s rhetoric and practice that is likely to influence students’ perceptions and behaviours in laboratory work;
- Incorporating inquiry-type activities in school science is inhibited by limitations in resources (including access to appropriate technology tools) and by lack of sufficient time for teachers to become informed and to develop and implement appropriate science curricula. Other inhibiting factors include large classes, inflexible scheduling of laboratory facilities, and the perceived foci of external and final examinations.

The nature and the sources of these problems need to be examined carefully and recommendations for policy and practice need to be based upon the findings of that research. There are important opportunities to pursue research and development building on what we know and on the scholarship of the past in order to enhance the effectiveness of science education. Special opportunities identified in this review include developing and assessing teaching strategies, assessment tools, and resources that are effective in helping teachers and students to attain important learning goals that:

- Engage students with different abilities, learning styles, motivational patterns, and cultural contexts;
- Engage students in using inquiry empowering tools and strategies;
- Engage students in justifying assertions on the basis of scientific evidence.

More particularly, this analysis of the scholarly literature in science education suggests the following implications:

- Goals for students’ learning outcomes must drive what is done by curriculum developers and by teachers in the classroom and the laboratory;
- Effective teaching engages, builds upon, and enhances students’ knowledge (conceptual and procedural), attitudes, perceptions, culture, etc.;
- Local and external assessment of students’ learning and attitudes must be consistent with the goals for learning outcomes;
- Classroom based research (i.e. action research) and development associated with curriculum and teaching is important in helping science teachers and students achieve important science learning outcomes;
- Appropriate teacher professional development, informed by relevant scholarship, is important in helping teachers to become more effective in teaching in student-centered inquiry-type science laboratories.
The development of inquiry-type experiments

About 100 inquiry-type experiments were developed and implemented in 11th and 12th grade chemistry classes in Israel (for more details about the development procedure, assessment of students’ achievement and progress, and the professional development of the chemistry teachers, see Hofstein, Shore & Kipnis, 2004). Almost all the experiments were integrated into the framework of the key concepts taught in high-school chemistry, namely: acids-bases, stoichiometry, oxidation-reduction, bonding, energy, chemical-equilibrium, and the rate of reactions. These experiments have been implemented in the school chemistry laboratory in Israel for the last five years (about 125 teachers in about 82 schools, and about 3500 students). Only teachers who underwent an intensive professional development (for more information see: Titelbaum, Mamlok-Naaman, Carmeli, & Hofstein, in press) were involved in teaching the inquiry laboratory program. In these professional development initiatives the teachers were given the opportunity to conduct all the stages of the inquiry experiments as will eventually be done by their own students.

Typically in this chemistry laboratory, the students perform the experiments in small groups (3-4), by following the instructions in the laboratory manual. Table 1 presents the various stages that each of the groups undergo in order to accomplish the inquiry task. In the first phase (the pre-inquiry phase), the students are asked to conduct the experiment based on specific instructions. This phase is largely ‘close-ended’, in which the students are asked to conduct the experiment based on specific instructions given in the laboratory manual. Thus, this phase provides the students with very limited inquiry-type experiences. The ‘inquiry phase’ (the second phase) is where the students are involved in more ‘open-ended-type’ activities such as asking relevant questions, choosing a question for further investigation, planning an experiment, hypothesizing, conducting the experiment (including observations) to accept or reject the hypothesis, and finally analyzing the findings and arriving at conclusions. It is assumed that this phase allows the students to learn and experience science with greater understanding, and also to practice their metacognitive abilities. White and Mitchell (1994) specify students' behaviours that, in their opinion, are characterized as: "good learning behaviors" for students who develop certain metacognitive skills. It is suggested that a large part of these behaviours (and skills) are actions that constitute an integral part of the inquiry laboratory activity. In addition, it is suggested that this approach provides the students with the opportunity to construct their knowledge by actually conducting authentic scientific work.

Researching the inquiry laboratory

The inquiry laboratory was researched extensively using a battery of instruments over a long period of time (1999-2007). The common feature of these studies is that they are all based on a comparison of two groups of chemistry students; a group of students who participated in the inquiry-type laboratory program with a group of students who participated in a more traditional-type laboratory method. The students in the later group were exposed to more structured-type, close-ended chemistry laboratory activities in which most of the experiences that were provided were confirmatory in nature. It should be noted that the topics taught and learned, text-books, and other learning experiences provided to the students, were similar in the two groups.

Three topics related to students learning, perceptions, and attitudes were researched:

- The students' abilities to ask questions while conducting an inquiry-type chemistry experiment (Hofstein, Shore, & Kipnis, 2004; Hofstein, Navon, Kipnis & Mamlok-Naaman, 2005).
- The students' perception of their classroom laboratory learning environment (Hofstein, Levy Nahum & Shore, 2001; Hofstein, 2006).
- The students' attitudes toward and interest in the chemistry laboratory (Kipnis & Hofstein, 2004; Kipnis & Hofstein, 2007).
- In addition, a study was conducted in which we researched the students ability to develop metacognitive skills while performing an inquiry experiment (Kipnis & Hofstein, on line IJSME;)

It is beyond the scope of this paper to provide details regarding the methodology and instruments used in each of the studies (more details could be found in the various published papers listed above).

In general, in all the above cited studies, it was found that the inquiry group out performed the comparison group regarding their perception of the class room laboratory learning environment more specifically; they found the learning environment more integrated in the subject matter, as providing more open-endedness, more difficult, and as providing a more satisfying learning environment compared to the comparison group. Also, the inquiry group
demonstrated a more favourable attitudes towards and interest in practical work. Regarding asking questions related to an experimental phenomenon, the inquiry group asked more relevant questions and also more high-order-type questions. In addition, we found that the inquiry group out performed the comparison group in their ability to observe, to hypothesise, and to plan an experiment for further investigations (i.e. reject or accept the hypothesis). (Kipnis & Hofstein submitted).

In the study that we have conducted regarding the potential of the inquiry laboratory to the development of metacognitive skills (Kipnis & Hofstein, on line in IJSME), it was found that while performing the inquiry activity, the students, whose activity was described above, practiced their metacognition in various stages of the inquiry process. This was expressed particularly in the following stages: (a) while asking questions and choosing an inquiry question, the students revealed their thoughts about the questions that were suggested by their partners and about their own questions. In this stage, the metacognitive declarative knowledge is expressed. (b) While choosing the inquiry question, the students expressed their metacognitive procedural knowledge by choosing the question that leads to conclusions. (c) While performing their own experiment and planning changes and improvements, the students demonstrate the planning component of regulation of cognition. (d) At the final stage of the inquiry activity, when the students write their report and have to draw conclusions, they utilize metacognitive conditional knowledge. (e) During the whole activity, the students made use of the monitoring and the evaluating components concerned with regulation of cognition. In this way, they examined the results of their observations in order to decide whether the results are logical.

DISCUSSION AND CONCLUSIONS

Based on these four studies we can conclude that the chemistry students who participated in this program obtained unique opportunities to be involved in a worthwhile learning process that the chemistry laboratory provided. In addition, it appears that it also provided them with an opportunity to learn in a preferable and meaningful learning environment that resulted in a more positive attitude toward the chemistry laboratory.

In recent years, there has been substantive growth in understanding associated with teaching, learning, and assessment in school science laboratory work. At the beginning of the 21st century, when many are again seeking reform in science education, the knowledge that has been developed about learning based upon careful scholarship should be incorporated in that reform. The "The less is more slogan" in "Benchmark for Science Literacy" (AAAS, 1993, p.320) has been articulated to guide curriculum development and teaching consistent with the contemporary reform. The intended message is that formal teaching results in greater understanding when students study a limited number of topics, in depth and with care, rather than a large numbers of topics much more superficially, as is the practice in many upper-secondary school science classrooms. In the Israeli case (described in this paper) in order to make room for the inquiry laboratories the syllabus (content) was reduced by 20%. Well designed, inquiry-type laboratory activities can provide learning opportunities that help student develop high-level learning skills. They also provide important opportunities to help students to learn to investigate (e.g. ask questions), to construct scientific assertions, and to justify those assertions in classroom community of peer investigators in contact with more expert scientific community. There is no doubt that such activities are time consuming and thus, the education system must provide time and opportunities for teachers to interact with their students and also time for students to perform and reflect on such and similar complex inquiry and investigative tasks. Such experiences should be integrated with other science classroom learning experiences in order to enable the students to make connections between what is learned in the classroom and what is learned and investigated in the laboratory. This is highly based on the growing sense that learning is contextualized and that learners construct knowledge by solving genuine and meaningful problems (Brown, Collins, & Duguit, 1989).

SUMMARY

To sum-up, based on the literature and findings of series of studies that we have conducted in Israel related to the educational effectiveness of the science laboratory we can assume that:

- School laboratory activities have special potential as media for learning that can promote important science learning outcomes for students;
- Teachers need knowledge, skills, and resources that enable them to teach effectively in practical learning environments;
- They need to be able to enable students to interact intellectually as well as physically, involving both hands-on investigation and minds-on reflection;

210
Students’ perceptions and behaviors in the science laboratory are greatly influenced by teachers’ expectations and assessment practices and by the orientation of the associated laboratory guide, worksheets, and electronic media;

Teachers need ways to find out what their students are thinking and learning in the science laboratory and classroom;

Teachers need to be provided with CPD opportunities to collaborate with colleagues in the science education research community so as to understand, develop, and teach in ways that are consistent with contemporary professional standards.

Epilogue

In 1980 Pickering wrote that:

The job of lab courses is to provide the experience of doing science. While the potential is rarely achieved, the obstacles are organizational and not inherent in laboratory teaching itself. That is fortunate because reform is possible and reform is cheap. Massive amounts of money are not required to improve most programs; what needed is more careful planning and precise thinking about educational objectives. By offering a genuine, unvarnished scientific experience, a lab course can make a student into a better observer, a more careful and precise thinker, and a more deliberative problem solver. And that is what education is all about.

Personally, although this essay was written almost 30 years ago I sincerely believe that it is also valid and relevant to date.

REFERENCES


Kipnis, M & Hofstein, A. Developing students’ inquiry skills resulting from inquiry-type chemistry laboratories, (submitted for publication)


This paper reports the results from the second year of a trial where pre-service primary teachers’ views of science and teaching science were deliberately challenged through weekly perturbing statements and associated readings within a science methods course. This explicit reflective approach to nature of science aimed to encourage the pre-service teachers to critically examine their prior beliefs, values and practices of teaching and learning science. The theoretical basis of this research was based upon a framework of facilitated reflection that included opportunity for reflection, expectations regarding the quality of reflection, and scaffolding to support the development of reflection as a skill. As a consequence of the explicit reflections, 82% of the pre-service teachers believed their views of science had been challenged, 80% of the pre-service teachers believed their views of science teaching and learning had been challenged, and 80% of the pre-service teachers believed the reflections assisted them in making the connection between their beliefs and actions. The pre-service teachers believed the weekly reflections encouraged them to consider how they would teach science in the future, addressed key issues in science teaching and learning, increased their knowledge of science strategies and concepts, were interesting and diverse, allowed them to express their own opinion, and allowed them to analyse the practice of others.

Key words: primary science teacher education, explicit reflective practice, nature of science

“THIS ISN’T SCIENCE, THIS IS LITERACY!”

There were giant green footprints leading into the workshop room. The sign on the door stated boldly “OGRE, BEWARE!” As we walked through the door we were transported into Shrek’s swamp. The tutor greeted the students by stating that she had found a strange green substance in the swamp, and needed their help to identify what it was. Each group of students was presented with an ice-cream container half full of the strange substance. [The substance being investigated was called ‘oobleck’ and consisted of cornflour, water and green food colouring. Oobleck is classified as slime, and behaves both as a solid and a liquid.] The students were informed that they had to investigate this substance by using all our senses, as well as describing how the substance moved. Then they had to decide what it might be. There was a lot of discussion and laughing within the groups as they set about exploring the unusual substance. One group came up with some great descriptions, such as green, icky, oozy, slimy, alien’s blood, squishy, smooth, runny, and shiny. The class then shared their ideas. There were even better descriptions used by the class. Such as tacky, pasty, rubbery, green icing sugar, a green marshmallow that you have sucked on and spat out, snot (oh gross!!), wet and dry at the same time, and lazy playdough. The class then had to draw a picture of the substance and write some words around the picture to describe it. They were encouraged to colour the picture. Some students used green highlighters while others used green pencils. Other students decided to put eyes on their picture to make it come alive, stating that it moved as if it was alive.

After this workshop, one student commented, “This isn’t science, this is literacy!” A second student agreed, and asked the tutor why they were doing a literacy activity in a science workshop.

This short vignette, which summarises a real workshop from a science methods course, illustrates various unique and challenging characteristics which pre-service primary teacher bring to their teacher education course. One of these characteristics is a limited understanding of what science is, known as ‘nature of science’. Many pre-service primary teachers perceive science as a fixed body of knowledge, totally objective, uncreative and
unimaginative, and driven solely by the scientific method (Appleton, 2006). Further, they do not recognize the everyday nature of science, or the changing nature of science (Olson & Appleton, 2006). The inability of these pre-service teachers to recognize the science component of the workshop, that they themselves were working as scientists, the place of creativity and imagination within the workshop, and that all answers provided were correct, highlighted their narrow views of science.

This paper presents the results from the second year of a trial where explicit reflection, in the form of weekly perturbing statements and associated readings, was used to challenge pre-service primary teachers’ views of science and science teaching. The purpose of this research was to evaluate the effectiveness of such an approach in terms of the pre-service teachers’ personal growth as a teacher of primary science, attitudes and beliefs about science teaching and learning being challenged, and personal growth as a reflective practitioner.

A REFLECTION ORIENTATION TO TEACHER EDUCATION

Reflection is the strategy that encourages teachers to think about their own teaching and learning. It requires the teacher to develop an understanding of themselves, by reflecting on and articulating their own learning experiences and processes (Hardy & Kirkwood, 1994). The reflective practitioner describes a teacher who analyses their teaching from various frames of reference, and combines personal experiences, values, and beliefs with theory and practice (Bain, Ballantyne, Mills, & Lester, 2002).

Teachers’ beliefs and attitudes towards teaching science have been found to influence the amount and quality of science that is taught in the primary classroom. Teachers with negative beliefs and attitudes towards science tend to spend less time teaching it; are more likely to employ didactic approaches rather than student-centred approaches; place heavy reliance on kits, prescriptive textbooks and worksheets; and avoid all but the simplest hands-on work (Appleton & Kindt, 1999; Bencze & Hodson, 1999; Harlen & Holroyd, 1997).

Various authors have advocated a reflection orientation to primary science teacher education as a means of providing meaningful experiences to pre-service teachers that enable them to critically examine their prior beliefs in order to initiate transformation in their thinking and teaching practices (Abell & Bryan, 1997; Bryan & Abell, 1999; Skamp, 1995; Zembylas & Barker, 2002). This reflection orientation stems from the scholarship of Dewey (1993) and Schön (1987), and is grounded in the belief that pre-service teachers learn to teach science through a process of re-evaluating and reforming their existing theories when confronted with perturbing evidence. Pre-service teachers enter primary methods courses holding ideas, beliefs and values that form their personal theories about science teaching and learning (Abell & Bryan, 1997). The reflection orientation is characterized by asking pre-service teachers to describe their ideas, beliefs and values about science teaching and learning and then providing experiences that help to clarify, confront, and possibly change such personal theories. Beginning teachers of science require many opportunities to inquire into and think critically about science teaching and learning. The reflection orientation to science preparation takes into account that future teachers learn about science in a number of different contexts, each providing the opportunity for reflection and learning (Abell & Bryan, 1997).

Campoy (2000) described a framework of facilitated reflection within teacher education. This framework included opportunity for reflection, expectations regarding the quality of reflection, and scaffolding to support the development of reflection as a skill. Opportunity for reflection refers to the provision of many and various opportunities to reflect upon coursework and/or field experiences of teaching. Campoy (2000) claimed that while many researchers include a variety of activities to promote reflection about teaching practices (such as journals, classroom discussion, portfolios, analyzing case studies, and videoed exemplary practice) they fail to include information on how to reflect. Expectation regarding the quality of reflection addresses the issue of what constitutes good and poor reflection, and the importance placed on supported opinion (Campoy, 2000). Campoy (2000) considered the use of a rubric to set standards for different levels of reflection, verbal and written feedback, modeling, and examples as effective means to address expectation. Scaffolding for reflection refers to course activities that support the development of reflective thinking through increasingly complex levels of reflection, such as metacognitive thinking (Campoy, 2000).

The framework of facilitated reflection was selected as the theoretical basis of the current research for three reasons. First, it allowed for transformative change by challenging the pre-service teachers’ thinking (Kagan, 1992). Second, the framework offered an holistic means of implementing the reflection process for the teacher educator, while also providing detailed information on the expectations of the reflections for the pre-service teachers. Third, the framework encouraged a culture of reflection where both the teacher educator and the pre-
service teachers could share, discuss and reflect upon certain learning experiences and the reflection process itself.

**NATURE OF SCIENCE**

Nature of science is concerned with how scientific knowledge is generated and the character of science itself (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). It relates to how science is done and how scientists go about doing their work. No specific definition has been attached to nature of science, highlighting the different interpretations presented in various fields of inquiry (philosophers, historians, sociologists of science or science educators), the multifaceted and complex nature of science, and the tentative and dynamic character of nature of science (Lederman et al., 2002). However, common aspects of nature of science include that science is tentative (subject to change); empirically based (based on and/or derived from observation of the natural world); subjective (theory-laden); partly the product of human inference, imagination and creativity (involves the invention of explanations); open and accountable; socially and culturally imbedded; there is no one way to do science (no universal ‘scientific method’); and laws and theories serve different roles in science (Abd-El-Khalick, Bell, & Lederman, 1998). Further, the use of the term ‘nature of science’, instead of ‘the nature of science’, has been used throughout research to convey the inability of commentators to achieve a single, agreed definition for nature of science (Abd-El-Khalick & Akerson, 2004). These common aspects of nature of science highlight how science is essentially a human activity and a dynamic process (Murcia & Schibeci, 1999).

Views of nature of science are tied to pre-service teachers’ beliefs about science teaching and learning. The ‘naïve’ conceptions of nature of science held by most pre-service teachers leads to a belief in a didactic approach of science instruction, where science is presented as a body of static knowledge (Abell, Martini, & George, 2001). The techniques used during science instruction are also perceived as being static, requiring minimal or no justification (Bartholomew, Osborne, & Ratcliffe, 2004). Pre-service teachers perceive science as a process of discovering what is out there, rather than as a human process of inventing explanations to describe how the world works. Similarly, pre-service teachers see learning as a process of acquiring knowledge through discovery (Abell & Smith, 1994). Such approaches have an emphasis on the product, rather than the processes of science. Further, such approaches to science instruction, which teach about what we know, inhibit any discussion on nature of science, the tentativeness of scientific knowledge, or the social dimensions of science (Bartholomew et al., 2004).

Techniques to improve nature of science in pre-service teachers have centred around the use of scientific inquiry, and explicit instruction through reflection (Abd-El-Khalick, 2001; Abd-El-Khalick & Akerson, 2004; Gess-Newsome, 2002). As a consequence of an inquiry course, Gess-Newsome (2002) found preservice teachers’ conceptions of science as primarily a body of knowledge (or product) changed to a more appropriate, blended view of science as a body of knowledge generated through the active application of scientific inquiry (process and product). Akerson, Abd-El-Khalick and Lederman (2000) found that an explicit reflective approach to nature of science instruction, within a science methods course, was effective in producing changes in elementary teachers’ views of nature of science. Internalising the importance of teaching about nature of science was found to be essential for pre-service teachers to address nature of science instructionally. Lederman (1999) considered nature of science such an important instructional objective that it should be a component of every science teacher education instructional unit, lesson and activity.

**METHODOLOGY**

Research paradigm

This research was guided by a practical action research methodology, distinguished by an iterative cycle of planning, action, observations, and reflection (Creswell, 2005). Action research enables researchers to “gather information about, and subsequently improve, the ways their particular educational setting operates, their teaching, and their student learning” (Creswell, 2005, p. 550). Through the process of action research, initiated by the workshop described at the start of this paper, perturbing reflections were developed that could challenge the pre-service teachers’ limited views of science and teaching science, while at the same time develop their reflective skills. The results presented in this paper continue the action research cycle by evaluating the effectiveness of the reflections as an agent of change.
Science methods course

The research was conducted over a science methods course during the third year of a 4-year Bachelor of Education degree at an Australian University. The course consisted of 10 weeks of workshops followed by a 3-week field experience. The weekly 3-hour workshops aimed to develop students’ pedagogical content knowledge through active scientific inquiry and ongoing reflection. The science learning experiences within the workshops were characterized by participation through an engage, explore, and explain model (Australian Academy of Science, 1994); placement within an authentic early childhood context; discussion of children’s views of science; and learning within a social constructivist environment. Explicit modelling and discussion of pedagogy was embedded into all workshops to provide opportunities for the pre-service teachers to observe, discuss and reflect upon various science teaching and learning strategies. The first 30 minutes of each workshop was allocated to the set reflections (see below for detail). The reflections comprised one of three assignments in the science methods course, and were worth 30% of the total marks for the course. The reflections were handed in twice during the semester: in Week 5 as formative assessment and again after the field experience as summative assessment. The author was the tutor during the workshops and the primary researcher in the data collection, analysis and interpretation.

Weekly reflections on nature of science

Approximately each week the pre-service teachers were presented with a reflection that contained a perturbing statement and associated reading to challenge the pre-service teachers’ views of science and science teaching. An additional two reflections were completed after field experience. The pre-service teachers completed a total of nine reflections. All reflections were presented in a self-contained booklet that included an introduction, purpose, and detailed assessment rubrics. These reflections are summarised in Table 1, with the title, a short description, and the purpose of the reflection. The perturbing statements, that were the title for each reflection (for example, 'Science is for boys only!'), were deliberately chosen to confront, motivate and engage the pre-service teachers. Different groups of pre-service teachers were responsible for facilitating each week’s reflection to encourage ownership and more discussion of the reflections.

Facilitated reflection was provided through opportunity, expectation and scaffolding. Opportunity to reflect was provided by weekly workshop discussions for each reflection. Within these discussions the pre-service teachers were constantly challenged as to why they believe the way they do, and where has that belief come from. This was supported by a detailed description of the purpose of the assignment within the reflection booklet. Each reflection had questions to be used as discussion points in the workshops, along with questions to direct the pre-service teachers’ individual reflections (see Table1). The latter consisted of three components: questions relating directly to the reflection, relating the reflection to future science teaching and learning, and reflecting on the challenges to personal science teaching and learning beliefs as a consequence of the reflection.

Expectations regarding the quality of reflection were provided through a detailed rubric that provided information on what was required for each grade level. Expectation was also provided through formative assessment, where the first four reflections were handed in part way through the semester. Detailed feedback was provided on these reflections, highlighting what the pre-service teacher was doing well, what needed to be improved, and how the reflection could be improved. Scaffolding for reflection was addressed by encouraging higher order thinking through questioning. As the pre-service teachers participated in the weekly workshops they were questioned about the characteristics of the activities. For example, the activity described at the start of this paper is characterised by open-endedness, inclusiveness and simplicity. Comparing these characteristics to those associated with their science learning experiences from high school, and then questioning and justifying the approach taken in the workshop, allowed the pre-service teachers to challenge their existing views of science and science teaching, while further developing their reflective skills.
Table 1: A summary of the explicit reflections used to challenge the pre-service primary teachers’ perceptions of science and teaching science

<table>
<thead>
<tr>
<th>#</th>
<th>Title</th>
<th>Short Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I hate science!</td>
<td>Write about a significant science event from school or your past. It can be positive or negative. Why is this event significant? How has this event influenced your attitude towards science?</td>
<td>To demonstrate how previous experiences shape current attitudes and beliefs. To encourage the pre-service teachers to explicitly describe what switched them off, or on, to science.</td>
</tr>
<tr>
<td></td>
<td>Philosophy of primary science teaching and learning</td>
<td>Provide a short overview of your personal philosophy of science teaching and learning before doing a science methods course.</td>
<td>To provide a comparison with the philosophy presented at the end of the science methods course.</td>
</tr>
<tr>
<td>2</td>
<td>All scientists wear lab coats!</td>
<td>The stereotype for a scientist is a crazy old man in a lab coat with hair sticking out. What is your perception of a scientist, and where has this view come from? How does this view compare with two profiles of scientists provided? How can children’s views of scientists be challenged?</td>
<td>Challenges the view that all scientists look and act in a similar way.</td>
</tr>
<tr>
<td>3</td>
<td>Science is for boys only!</td>
<td>Read a published journal article on gender inclusivity in science education. Describe techniques used by the teacher to provide a gender inclusive classroom. How can you apply these in your future classroom when teaching science?</td>
<td>Challenges the view that there are no gender issues in primary science.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Challenges the perception that only males can be good at science.</td>
</tr>
<tr>
<td>4</td>
<td>Science is unimaginative and uncreative!</td>
<td>The following quote from Einstein is presented: <em>Imagination is more important than knowledge.</em> What are the characteristics of a creative child? What is the place of creativity in the teaching and learning of science?</td>
<td>Challenges the perception that science is uncreative and unimaginative.</td>
</tr>
<tr>
<td>5</td>
<td>There is only one way to do science!</td>
<td>Science photography and science posters are presented as alternatives to the scientific method. What are the advantages and limitations of using alternative forms of doing science in the classroom? How can more alternative forms of doing science be incorporated into the primary classroom?</td>
<td>Challenges the perception that there is only one way to do science – via the scientific method.</td>
</tr>
<tr>
<td>#</td>
<td>Title</td>
<td>Short Description</td>
<td>Purpose</td>
</tr>
<tr>
<td>----</td>
<td>-------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>6</td>
<td>Science is just a body of knowledge!</td>
<td>Two excerpts from a published journal article are presented – one showing science as a process, the other as a product. Critique the two excerpts in relation to the pedagogy used by the teacher. How can you make sure that you cover both the product and process of science in your future teaching and learning of science?</td>
<td>Challenges the perception that science is just a body of knowledge.</td>
</tr>
<tr>
<td>7</td>
<td>Science has the answer to everything!</td>
<td>A short case study is presented based upon a fictitious pre-service primary teacher during practicum. In a class discussion after an investigation on the reflection of light, the teacher answers all the student’s questions. If you were the cooperating teacher observing this lesson, what advice would you provide to the pre-service teacher.</td>
<td>Challenges the perception that science is just a body of knowledge, and that science has the answer to everything. Challenges the perception that in order to teach science you must know the answer to everything.</td>
</tr>
<tr>
<td>8</td>
<td>Was there science taught at my school?</td>
<td>Six questions are presented in relation to the amount of science that was taught, or witnessed, while on practicum.</td>
<td>To demonstrate the small amount of science that is taught at primary school, and some teacher’s attitudes towards science.</td>
</tr>
<tr>
<td>9</td>
<td>How have I changed?</td>
<td>How have your attitudes, philosophy, and confidence of teaching and learning science changed over the science methods course?</td>
<td>To allow the pre-service teachers an opportunity to reflect and describe how they believe they have been challenged or changed over the science methods course.</td>
</tr>
</tbody>
</table>

Data collection and analysis

Data was collected from one class of 29 pre-service teachers using two questionnaires: Science Reflections questionnaire and Reflecting on Reflecting questionnaire. The Science Reflections questionnaire consisted of 18 items that asked the pre-service teachers how the reflections influenced their thinking about science, thinking about science teaching and learning, thinking about reflecting, sharing reflections in the workshop, and how relevant the reflections were to their needs as learners. Each item was responded to on a five-point Likert scale with the alternatives of ‘strongly disagree’, ‘disagree’, ‘neutral’, ‘agree’, and ‘strongly agree’. The Science Reflections questionnaire was given to the students at the end of the semester. Quantitative data from this questionnaire were summarised as percentages and presented in tables.

The Reflecting on Reflecting questionnaire was the last page in the Reflection booklet. It consisted of three open-ended questions to obtain more detailed qualitative information on how and why the reflections had challenged the pre-service teachers. The following questions were used:
1. How have the reflections helped you to grow as a teacher of science?
2. How have the reflections challenged your attitudes and/or beliefs about the teaching and learning of science?
3. How have the reflections helped you to grow as a reflective practitioner?
These questions were chosen to highlight the pre-service teachers developing philosophy of science teaching and learning, and their growth as a teacher of science as a result of the reflection assignment. The pre-service
teachers were encouraged to answer the Reflecting on Reflecting questionnaire in their own time and hand it in with their final reflection assignment that was due after their field experience. A total of 14 (or 48%) of the pre-service teachers completed the Reflecting on Reflecting questionnaire.

Findings

Table 2 summarises the results of the Science Reflections questionnaire. Three quarters of the pre-service teachers responded in a positive manner (‘agree’ or ‘strongly agree’) to all but one question. Findings are presented below in five sections, relating to the five sections of the Science Reflections questionnaire. These results are supported by the pre-service teachers’ statements from the Reflecting on Reflecting questionnaire.

Thinking about science

As shown in Table 2, more than eighty percent of the pre-service primary teachers’ believed that the reflections had assisted them in thinking more about science. Eighty six percent of the pre-service teachers believed the reflections assisted them to think more carefully about their own ideas of science, and to become clearer about their own views of science. Eighty two percent of the pre-service teachers believed the reflections assisted them in challenging their own views of science.

Comments from the pre-service teachers to highlight these points are presented below.

They made me ‘think’ about science as something other than boring and scary; something only ‘smart’ people do. [2007, C1]

The reflections posed points of view, ideas and concepts that I previously had not considered (influence of gender) when thinking about science. [2007, C13]

I have explored in more detail what science is, its contribution to society, and what it offers. [2007, D6]

I used to view science as a stale and rigid learning area (as a result of my own experiences in school), and now I acknowledge the creativity and usefulness of science if taught correctly and made student-centred. [2007, D9]

I could not see how science could be interesting and engaging. I thought science was something males are generally better at. I did not realise the connection between creativity and science. [2007, D14]

Thinking about science teaching and learning

Eighty percent or more of the pre-service primary teachers’ believed that the reflections had assisted them in thinking more about science teaching and learning (see Table 2). Ninety percent of the pre-service teachers believed the reflections assisted them to think more carefully about their own ideas of science teaching and learning. Eighty percent of the pre-service teachers believed the reflections had assisted them in challenging their own views of science teaching and learning, and to become clearer about their own views of science teaching and learning. Comments from the pre-service teachers to highlight these points are presented below.

The reflections as a whole helped me grow as a teacher as it gave opportunity to discuss and reflect on existing ideas about science teaching and learning. The reflections also highlighted important factors about science teaching which I might have never thought about. [2007, C3]

It has really made me think about how I would want to teach science in my classroom and the different teaching strategies I would use. [2007, C5]

They helped me to define my ideas regarding science teaching and learning and I learnt a lot. [2007, C7]

The reflections have strengthened my beliefs about science teaching and learning. The unit has opened up my eyes to what science can offer to students. [2007, D5]

I know recognise the importance of diversity and focussing on science processes, not just product. [2007, D7]
Table 2: Percentage response of the pre-service teachers from the *Science Reflections* questionnaire (n = 29)

<table>
<thead>
<tr>
<th>Scale/Item</th>
<th>SD</th>
<th>D</th>
<th>N</th>
<th>A</th>
<th>SA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Thinking about science</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1. The reflections assisted me in thinking more carefully about my own ideas of science.</td>
<td>0</td>
<td>7</td>
<td>7</td>
<td>48</td>
<td>38</td>
</tr>
<tr>
<td>A2. The reflections assisted me in challenging my own views of science.</td>
<td>0</td>
<td>3</td>
<td>14</td>
<td>48</td>
<td>34</td>
</tr>
<tr>
<td>A3. The reflections assisted me in becoming clearer about my own views of science.</td>
<td>0</td>
<td>3</td>
<td>10</td>
<td>55</td>
<td>31</td>
</tr>
<tr>
<td><strong>B. Thinking about science teaching and learning</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1. The reflections assisted me in thinking more carefully about my own ideas of science teaching and learning.</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>59</td>
<td>31</td>
</tr>
<tr>
<td>B2. The reflections assisted me in challenging my own views of science teaching and learning.</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td>52</td>
<td>28</td>
</tr>
<tr>
<td>B3. The reflections assisted me in becoming clearer about my own views of science teaching and learning.</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td>52</td>
<td>28</td>
</tr>
<tr>
<td><strong>C. Thinking about reflecting</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. The reflections assisted me in thinking more carefully about the reflection process.</td>
<td>3</td>
<td>7</td>
<td>28</td>
<td>55</td>
<td>7</td>
</tr>
<tr>
<td>C2. The reflections assisted me in thinking more critically about science related issues.</td>
<td>3</td>
<td>0</td>
<td>14</td>
<td>59</td>
<td>24</td>
</tr>
<tr>
<td>C3. The reflections assisted me in making the connection between my beliefs and my actions.</td>
<td>3</td>
<td>0</td>
<td>17</td>
<td>59</td>
<td>21</td>
</tr>
<tr>
<td><strong>D. Sharing reflections in the workshop</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1. I was open to other students’ opinions in class.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>45</td>
<td>55</td>
</tr>
<tr>
<td>D2. I respected ideas that were different to mine.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>D3. I appreciated the different views expressed in the class.</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td><strong>E. The reflections</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1. Addressed key issues in science teaching and learning.</td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>69</td>
<td>24</td>
</tr>
<tr>
<td>E2. Were interesting and diverse.</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>45</td>
<td>34</td>
</tr>
<tr>
<td>E3. Allowed me to express my own opinion.</td>
<td>0</td>
<td>7</td>
<td>10</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>E4. Allowed me to analyse the practice of others.</td>
<td>0</td>
<td>3</td>
<td>17</td>
<td>66</td>
<td>14</td>
</tr>
<tr>
<td>E5. Increased my knowledge of science strategies and concepts.</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>62</td>
<td>28</td>
</tr>
<tr>
<td>E6. Made me consider how I will teach science in the future.</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>45</td>
<td>52</td>
</tr>
</tbody>
</table>

*Note.* Each item was responded to on a five-point Likert scale with the alternatives of SD = ‘strongly disagree’, D = ‘disagree’, N = ‘neutral’, A = ‘agree’, and SA = ‘strongly agree’.
Thinking about reflecting

As shown in Table 2, eighty three percent of the pre-service teachers believed the reflections assisted them to think more critically about science related issues. Eighty percent of the pre-service teachers believed the reflections had assisted them in making the connection between their beliefs and their actions. Comments from the pre-service teachers to highlight these points are presented below.

I have been made to think about how I’ll teach science in the future and reflect on how my thoughts have changed in a more positive way [2007, C11]

It has made me realise and challenge the way I think about science as a daily occurrence [2007, E8]

They forced me to identify my attitudes, values and beliefs. In doing so, I discovered that I was prejudice in some areas and actively challenged these attitudes. [2007, E12]

I can see how my attitudes and beliefs about science can influence the children I teach, positively or negatively, depending on my view and attitudes. It is therefore important to examine these and how they will affect your teaching. [2007, E14]

In contrast, sixty two percent of the pre-service teachers believed the reflections assisted them to think more carefully about the reflection process. Two positive and negative examples are presented below to illustrate the different beliefs of the pre-service teachers towards the usefulness of the reflections.

They really got me thinking and enabled me to define some of my beliefs and attitudes regarding science teaching and learning. [2007, F7]

Learning is taken to a deeper level when you are forced to think about new knowledge and how it connects with already existing schemes and perceptions. [2007, F9]

I don’t really think I have grown as a reflective practitioner … I still don’t feel very confident in my reflecting. I find it hard to explain how my thinking has changed or explain why it hasn’t. [2007, E3]

I’m a bit over reflecting. I understand reflection in regards to planning and programs but for each week … it becomes a bit much. [2007, E6]

Sharing reflections in the workshop

All pre-service teachers believed that sharing the reflections within the workshops had been beneficial to their understanding of the reflections (see Table 2). All pre-service teachers believed they were open to other students’ opinions in class, respected ideas that were different to their own, and appreciated the different views expressed in the class.

Relevance of the reflections

Over three-quarters of the pre-service teachers found the reflections relevant to their needs (see Table 2). Ninety seven percent of the pre-service teachers believed the weekly reflections encouraged them to consider how they would teach science in the future. Ninety three percent of the pre-service teachers believed the reflections addressed key issues in science teaching and learning. Ninety percent of the pre-service teachers believed the reflections had increased their knowledge of science strategies and concepts. Eighty three percent of the pre-service teachers believed the reflections allowed them to express their own opinion. Eighty percent of the pre-service teachers believed the reflections allowed them to analyse the practice of others. Seventy nine percent of the pre-service teachers believed the reflections were interesting and diverse.

Discussion and Implications

The results from this research highlight the value of deliberately challenging pre-service primary teachers’ views of science and science teaching and learning through an explicit reflective approach. The use of the perturbing statements and associated readings, along with class discussion, assisted the pre-service teachers to critically examine and challenge their prior beliefs, attitudes and practices of teaching and learning science. The pre-service teachers believed that as a consequence of these reflections they had grown as teachers of science and as reflective practitioners. These results support those found by Abd-El-Khalick (2001) where an explicit reflective approach
approach through activities, readings and active discourse was found to enhance pre-service primary teachers’ nature of science.

The positive feedback from the pre-service teachers highlighted their growth and understanding of science, science teaching and learning, and reflection. Previous research that investigated methods of challenging nature of science had been interpreted solely from the science perspective (Abd-El-Khalick, 2001; Gess-Newsome, 2002). The results presented in this paper illustrate how challenging views, and the use of the reflection process, go hand-in-hand. The benefits of such an explicit reflective approach are thus doubled when both perspectives are addressed.

The explicit reflective approach to challenging views can be applied to any discipline, where students’ prior beliefs and attitudes have to be explored, discussed and confronted, and where the relationship between belief and practice must be realised. Perturbing statements and accompanying readings, cases, dilemmas, videos, or posters can be developed to fit the required discipline. These materials should be deliberately provocative and address major issues within the discipline, encouraging the students to think about and question their beliefs. This type of reflection can, and should be, readily updated to reflect the dynamic nature of the discipline under study.

Providing time and space for reflections was considered very important to these pre-service teachers. The sharing of experiences, and the opportunity to discuss their own personal views and where these views had come from, was considered a very valuable part of the whole reflection experience for the pre-service teachers.

The explicit reflective approach to challenging views of science, based on perturbing statements and associated readings, provided experiences from which the pre-service primary teachers discovered, questioned, challenged, and refined their own attitudes and beliefs about science, the teaching and learning of science, and the reflective process.

References


Abstract

A new skipped grid for the spherical coordinates is proposed based on the concept of equal-area grid. This method avoids computational problems at the poles. Application of this new skipped grid to the shallow water equations with a standard test case gives the result that has the same accuracy as the uniform grid with equivalent number of grid points.

Keywords: skipped grid; shallow water equations

Introduction

Fluid flow happens at any place and at any time, for examples the flows of water in duct or air in chimney. The Navier-Stokes equations are the complete set of equations that describe fluid flow but they are very complex and complicated to apply in the real world. Thus, it is necessary to simplify the equations to applicable forms. Shallow water equations, a simplified version of the Navier-Stokes equations, is widely used in many fields including atmospheric and oceanographic studies. For large scale flow such as circulations of the atmosphere and oceans, spherical shape of the earth must be taken into account when formulating the equations. This results in spherical shallow water equations model, which is important for atmospheric and oceanic numerical model development and applications. For examples, it is a basic model for atmospheric prediction, climate change study and pollution dispersion in the atmosphere. Although simplified from the full set of equations, the shallow water equations still maintain an important property, nonlinear behavior. The importance of weather processes and forecasting is well understood, as weather affects us in a multitude of ways through agriculture, building, and transportation. The accuracy of climate and weather forecasting depends on many factors, among these are the accuracy of the knowledge of the state of the atmosphere at initial time, the numerical methods applied, and the resolution used in the numerical methods. Scientific communities are interested in studying accurate and efficient methods for these problems. One way to achieve high accuracy in climate and weather forecasting computations is to use high order discretization methods. However, computational atmospheric problems are known to be very time consuming when high resolution numerical models are used. In this paper, a skipped grid is proposed to reduce the number of grid point used in numerical simulation of the SWE in order to decrease the CPU time required for the simulation but still maintain the accuracy of the simulation.

NEW SKIPPED GRID

Spherical Cap

Spherical cap, (Figure 1A) and spherical segment, (Figure 1B) are related. In geometry, a spherical cap is a portion of a sphere cut off by a plane. The cap is a called a hemisphere if the plane passes through the center of the sphere and it is called a spherical segment if the cap is cut by a second plane. A spherical segment is the solid defined by cutting a sphere with a pair of parallel planes (Harris and Stocker, 1998). The region of the spherical segment is called a zone.
The height of the pair of parallel planes is \( h \), the mean radius of the earth is \( R \), and the surface area is given by \( S \). The surface area of spherical cap and zone are represented by the same equation because the surface area formula depends only on the height of the zone. Since area of grid should be less than 10,000 \( km^2 \) because this scale is accepted in atmospheric and oceanic works for global-scale study. Therefore, in this paper the \textit{fixed-area} is set to 10,000 \( km^2 \).

Since

\[
S = 2\pi Rh
\]

Let \( \phi = 89^\circ, R = 6372.7954 \text{ km} \)

\[
S = 2\pi R(R - R\sin 89^\circ) = 38865 \text{ km}^2
\]

If the spherical cap is separated into 4 sections (the value at a pole is estimated from the value at the 4 surrounding points), then its area is 9716.1 \( km^2 \)

**Spherical Segment**

The method proposed in this research is not the same as spline collection because the number of subintervals along the latitudinal dimension need not to be \( 2^N \) (\( N \) is a positive integer) and a pair of latitude can be expanded or reduced. Moreover, the cell area is concentrated and can be determined because the grid configuration results in cell that developed into almost equal grid.

The inequality of an equal grid is defined by

\[
\frac{\text{fixed-area}}{2} \leq \frac{2\pi R^2 (\sin\phi_i - \sin\phi)}{N_i} \leq \text{fixed-area}
\]

and \( \frac{360}{N_i} \in I^+ \). If \( a < b \), then \( N_a \leq N_b \) and \( \frac{N_b}{N_a} \in I^+ \) \hspace{1cm} (1)

\[
\Delta x \leq 2.5\Delta y \text{ and } \Delta y \leq 2.5\Delta x \hspace{1cm} (2)
\]

where

\textit{fixed-area} means supremum of the area.

\( I^+ \) is a positive integer.

\( i \) is the index of latitudes

\( N_i \) is the number of grid points at \( i \)
\(a\) and \(b\) are elements of \(i\)

\(\phi_2\) (or \(\phi_1 + \Delta \phi\)) is immediately above \(\phi_1\) if latitude \((\phi)\) is in the northern hemisphere

\(\phi_2\) (or \(\phi_1 - \Delta \phi\)) is immediately below \(\phi_1\) if latitude \((\phi)\) is in the southern hemisphere

\(\Delta x\) is a length in the east-west direction for a spherical rectangle on the globe.

\(\Delta y\) is a length in the north-south direction for a spherical rectangle on the globe.

The spherical rectangle on the globe is enclosed by two longitudes which are \(\lambda\) and \(\lambda + \Delta \lambda\) and two latitudes which are \(\phi\) and \(\phi + \Delta \phi\). The length of its sides are \(R \cos \phi \Delta \lambda\) and \(R \Delta \phi\), respectively. Infinitesimal changes in latitude \(\phi\) and longitude \(\lambda\), and the average radius of earth \(R\) are related to infinitesimal changes in \(x\) and \(y\) as shown in Figure 2.

\[\Delta x = \frac{(2\pi R \cos \phi_1)}{N_i}\]

\[\Delta y = \left|\phi_2 - \phi_1\right| \times 60 \times 1.852 \text{ km}\]

For example, the largest area formed by the grids is between \(\phi_2 = 74^\circ\) and \(\phi_1 = 73^\circ\). The lengths of the sides are \(\Delta x = (2\pi R \cos 73^\circ)/128 = 91.4608 \text{ km}\), and \(\Delta y = (74^\circ - 73^\circ) \times 60 \times 1.852 = 111.12 \text{ km}\). The area is \(2\pi R^2 \left(\sin 74^\circ - \sin 73^\circ\right)/128 = 9882.0 \text{ km}^2\). On the other hand, the smallest area is between \(\phi_2 = 55^\circ\) and \(\phi_1 = 54^\circ\). The lengths of the sides are \(\Delta x = (2\pi R \cos 73^\circ)/512 = 45.9683 \text{ km}\) and \(\Delta y = (55^\circ - 54^\circ) \times 60 \times 1.852 = 111.12 \text{ km}\). The area is \(2\pi R^2 \left(\sin 55^\circ - \sin 54^\circ\right)/512 = 5051.2 \text{ km}^2\).

**Skipped Grid**

Skipped-grid is a method that avoids numerical problems associated with the poles in the spherical coordinates. Skipped-grid method is constructed by Jochen Gottelmann (1999) as shown in Figure 3.
Layton (2002) constructed cubic spline on a skipped grid. He showed that the skipped-grid method is more efficient than the longitude–latitude grid point method. The skipped-grid method is a good method but equal-grid methods are more popular because they are very accurate. In this paper a new skipped-grid with equal area is proposed. The new skipped-grid is the same as the skipped-grid but the formulation is not the same. The new skipped-grid formulation is shown in Section 2.2. The skipped-grid formulation of Jochen Göttelmann (1999) is a spline collection method. In the new skipped-grid, numbers of grid points are maximum (512 grid points) at the equator. The numbers of grid points is decreased at high latitudes because the zone (area of the spherical segment) near the pole is smaller than the zone away the pole. If the grids are equal-area, then the numbers of grids on a pair of high latitudes will be decreased. In this study, the numbers of grid points which are the nearest to the pole are 4 points. The value at the pole is estimated from the value at the 4 surrounding points. By this procedure the pole problem is eliminated.

EXPERIMENT CASES

Model 1 and Model 2

Two grid configurations are used in this paper. Model 1 is a uniform grid (Figure 4). There are 380 lines in the y-axis and 179 lines in the x-axis. (All longitudes and latitudes in this model are shown in Section 3.3). Therefore, there are 68020 grid points in Model 1.

In Model 2 the new skipped-grid is used. There are 68008 grid points in this model. All longitudes and latitudes of Model 2 are also shown in Section 3.3.

Numerical Method

The shallow water equations are a set of equations used in modeling of fluid flow. They are particularly well suited and often used to test numerical techniques for weather prediction. The equations are as follows

\[
\frac{\partial u}{\partial t} + \frac{u}{R \cos \phi} \frac{\partial u}{\partial \lambda} + \frac{v}{R} \frac{\partial u}{\partial \phi} - \left( f + \frac{u \tan \phi}{R} \right) v + \frac{g}{R \cos \phi} \frac{\partial h}{\partial \lambda} = 0
\]
where \( f \) is the Coriolis parameter, \( g \) is the acceleration due to gravity, \( R \) is the mean radius of the sphere, \( h \) is the depth of the fluid layer, and \( u \) and \( v \) are the speed of fluid in the \( \lambda \) and \( \phi \) direction respectively.

**Model 1**

Forth-order central difference is used as follow

**Zonal Derivatives**

\[
\frac{\partial \varphi}{\partial \lambda_{i,j}} = \frac{-\varphi_{i+1,j} + 8\varphi_{i,j} - 8\varphi_{i-1,j} + \varphi_{i-2,j}}{12\Delta \lambda} + O(\Delta \lambda^4)
\]

**Meridional Derivatives**

\[
\frac{\partial \varphi}{\partial \phi_{i,j}} = \frac{-\varphi_{i,j+1} + 8\varphi_{i,j} - 8\varphi_{i,j-1} + \varphi_{i,j-2}}{12\Delta \phi} + O(\Delta \phi^4)
\]

Note: \( \varphi \) can be \( u, v, \) or \( h \).

**Model 2**

Zonal derivatives in Model 2 is the same as Model 1. Meridional derivatives used for all area but the point which is a skipped point is not calculated with gridding method. If the area is in the northern hemisphere then the value of a skipped point \((i, j + 1)\) is estimated with the right point \((i + 1, j + 1)\) and the left point \((i - 1, j + 1)\). In the same way, if the area is in the southern hemisphere then the value of a skipped point \((i + 1, j - 1)\), is evaluated with the right point \((i + 1, j - 1)\), and the left point \((i, j - 1)\). These special cases are shown in Figure 5.

The evaluation of a skipped point is

\[
\varphi_i \approx \frac{\varphi_{i-1} + \varphi_{i+1}}{2}
\]

**Error Analysis**

Williamson et al. (1992) constructed the standard test set which consists of seven test cases. Test cases 1 to 4 have analytic solutions, but test cases 5 to 7 have no analytic solutions. In this paper, test case 1, advection of cosine bell,
is used. The numerical solutions of high-resolution spherical harmonics model are regarded as true solutions in error measurements. The following normalized global errors are used for error measurements in this study.

**Model 1**

Define $I$ (of Model 1) to be a discrete approximation to the global integral

$$I(h) = \int_{-\pi}^{\pi} \int_{-\pi/2}^{\pi/2} h(\lambda, \phi) \cos \phi d\phi d\lambda = \sum_{\lambda} \sum_{\phi} h(\lambda, \phi) \cos \phi$$

where $h$ is a physical quantity of the numerical solution.

All longitudes are

$$\lambda = \{-180^\circ, -180^\circ + \frac{360^\circ}{380}, -180^\circ + (2) \frac{360^\circ}{380}, ..., 180^\circ - \frac{360^\circ}{380}\}$$

All latitudes are

$$\phi = \{-89^\circ, -88^\circ, -87^\circ, ..., 89^\circ\}$$

**Model 2**

In the same way, $I$ is calculated with all grid points. Hence, the function $I$ (of Model 2) is given by,

$$I(h) = \sum_{\lambda_d} h(\lambda_d, \phi_d) \cos \phi_d + \sum_{\lambda_b} h(\lambda_b, \phi_b) \cos \phi_b + \sum_{\lambda_c} h(\lambda_c, \phi_c) \cos \phi_c + \sum_{\lambda_d} h(\lambda_d, \phi_d) \cos \phi_d + \sum_{\lambda_e} h(\lambda_e, \phi_e) \cos \phi_e + \sum_{\lambda_f} h(\lambda_f, \phi_f) \cos \phi_f + \sum_{\lambda_g} h(\lambda_g, \phi_g) \cos \phi_g$$

All longitudes are

$$\lambda_d = -180^\circ, -180^\circ + \frac{360^\circ}{512}, -180^\circ + (2) \frac{360^\circ}{512}, ..., 180^\circ - \frac{360^\circ}{512}$$

$$\lambda_b = -180^\circ, -180^\circ + \frac{360^\circ}{256}, -180^\circ + (2) \frac{360^\circ}{256}, ..., 180^\circ - \frac{360^\circ}{256}$$

$$\lambda_c = -180^\circ, -180^\circ + \frac{360^\circ}{128}, -180^\circ + (2) \frac{360^\circ}{128}, ..., 180^\circ - \frac{360^\circ}{128}$$

$$\lambda_g = -180^\circ, -180^\circ + \frac{360^\circ}{64}, -180^\circ + (2) \frac{360^\circ}{64}, ..., 180^\circ - \frac{360^\circ}{64}$$

$$\lambda_w = -180^\circ, -180^\circ + \frac{360^\circ}{32}, -180^\circ + (2) \frac{360^\circ}{32}, ..., 180^\circ - \frac{360^\circ}{32}$$

$$\lambda_v = -180^\circ, -180^\circ + \frac{360^\circ}{16}, -180^\circ + (2) \frac{360^\circ}{16}, ..., 180^\circ - \frac{360^\circ}{16}$$

$$\lambda_d = -180^\circ, -180^\circ + \frac{360^\circ}{4}, -180^\circ + (2) \frac{360^\circ}{4}, ..., 180^\circ - \frac{360^\circ}{4}$$

All latitudes are

$$\phi_d = 89^\circ$$

$$\phi_b = -89^\circ$$

$$\phi_c = 86^\circ, 87^\circ$$

$$\phi_d = 82^\circ, 83^\circ, 84^\circ, 85^\circ$$

229
\phi_e = 73^\circ, 74^\circ, ..., 81^\circ \quad \text{and} \quad -73^\circ, -74^\circ, ..., -81^\circ \\
\phi_f = 55^\circ, 56^\circ, ..., 72^\circ \quad \text{and} \quad -55^\circ, -56^\circ, ..., -72^\circ \\
\phi_g = -54^\circ, -53^\circ, ..., 53^\circ, 54^\circ 

The following norms were calculated

\[ l_1(h) = \sqrt{\left(\left\Vert \hat{h}(\lambda, \phi) - h_T(\lambda, \phi) \right\Vert \right)^2 / \left\Vert h_T(\lambda, \phi) \right\Vert^2} \]

\[ l_2(h) = \sqrt{\left(\left\Vert \hat{h}(\lambda, \phi) - h_T(\lambda, \phi) \right\Vert \right)^2 / \left\Vert h_T(\lambda, \phi) \right\Vert^2} \]

\[ l_\infty(h) = \max_{\lambda, \phi} \left(\left\Vert \hat{h}(\lambda, \phi) - h_T(\lambda, \phi) \right\Vert / \max_{\lambda, \phi} \left\Vert h_T(\lambda, \phi) \right\Vert \right) \]

where \( h_T \) is a physical quantity of the true solution.

**Results**

**Initial Cosine Bell**

For this test case 1 of Williamson et al. (1992), the cosine bell should simply be pushed around the sphere. Ideally, after one rotation, the cosine bell should end up back in the middle of the grid and look the same as the initial condition (the shape of the bell should be preserved). Test case 1 for Model 1 and Model 2 are shown for \( \alpha = (\pi / 2) - 0.05 \) (\( \alpha \) is the angle between the axis of solid body rotation and the polar axis of the spherical coordinate system) to verify the numerical stability of advection the cosine bells near the pole in Figure 6.

![Initial cosine bells for Model 1 (A) and Model 2 (B)](image)

A B

Figure 6: Initial cosine bells for Model 1 (A) and Model 2 (B)

Model 1 has 68020 grid points and Model 2 has 68008 grid points. They are almost equal in number of grid points. Initial cosine bells for Model 1 (Figure 6A) and Model 2 (Figure 6B) are almost the same.

**A Comparison of the Results**

Figure 7A, shows the result of Mode 1 after 2 days of integration using the forth-order central difference. It’s almost the same as the analytic solution. The nonphysical oscillations behind the cosine bell are invisible. Figure 7B, shows the result of Mode 2 after 2 days of integration using the forth-order central difference. It’s almost the same as Model 1. The nonphysical oscillations behind the cosine bell are also unnoticeable in this figure.
Error Analysis

Figure 8 shows errors of Model 1 and Model 2. They are sampled 40,000 times and the calculation is done with the time step of 5 s.

These figures show the values of $l_1(h)$, $l_2(h)$, and $l_\infty(h)$ after 2 days. The two methods are similar between first step to 20,000 steps but Model 2 is better than Model 1 after 20,000 steps (because norms of Model 2 are smaller than model 1). The two models are of the same efficient.

Conclusions

The proposed skipped grid is a method that avoids numerical problems associated with the pole in spherical coordinates. In this method the grid points are arranged as close as possible to an equal-area grid. An application of the new skipped grid to the standard Test case 1 for the shallow water equations shows that this method provides equivalent accuracy and stability as a uniform grid with almost the same number of grid points.
References


AN INTERDISCIPLINARY INVESTIGATION OF HIGH SCHOOL STUDENTS’ APPROACHES TO LEARNING SCIENCE: THE RELATIONS AMONGST ACHIEVEMENT- GOALS, CONSTRUCTIVIST PEDAGOGICAL DIMENSIONS, MOTIVATIONAL BELIEFS AND SELF-REGULATED LEARNING

Michael R. Iverach and Darrell L. Fisher
Curtin University of Technology
Australia

ABSTRACT

The research presented was designed to address the assumption that important social- and personal-based constructs associated with achievement goals, constructivist-based pedagogy, motivational beliefs and self-regulated learning act in an interdisciplinary fashion to influence high school students’ approaches to learning science. A large-scale quantitative study (n = 655) of year 9 and year 11 science students attending regular and selective high schools in an Australian state education system yielded a single-level structural equation model that was applicable to the general high school science student after controlling for the variance associated with age, gender, and student type (regular or selective high school student). Results found support for the hypothesis that a perceived emphasis on the constructivist-based pedagogical dimensions of personal relevance and student negotiation in science classrooms potentially promotes the adoption of mastery-approach and intrinsic value. These analyses also showed the importance of self-efficacy and mastery-approach in promoting the use of regulatory strategies, and that test anxiety had positive associations with performance-avoidance goals. Implications for the research disciplines studied are presented in terms of teaching practice, theory, future research and research methods.

INTRODUCTION

Relatively recent advances in research affiliated with “teaching for understanding” has focused on the usefulness of constructivist-based pedagogy, acknowledging that the learning environment features that accompany social constructivist settings compliment the cognitive constructions employed by students as they learn (Andre & Windschitl, 2003; Blumenfeld, Marx, Patrick, Krajcik, & Soloway, 1997; Hatano & Inagaki, 2003; Vosniadou, 2003). However, over the past two decades a substantial amount of education research on “teaching for understanding” and “learning for understanding” processes has also occurred in the fields of achievement goals and self-regulated learning. The fields of inquiry associated with each of these research disciplines have convergent research aspirations in that they consider in some form the impact of environmental/social and personal factors on the quality learning processes employed by students. While research on the interactions between achievement goals and self-regulated learning has been interdependent, scant attention has been made between the interaction of constructivism, particularly constructivist-based pedagogy (“social constructivism”), with achievement goals and self-regulated learning. The present research addresses this deficiency by modelling the interactions of important constructs affiliated with these three fields in the context of high school science students.

Contemporary achievement goal theory is concerned with four types of personal achievement goals (mastery-approach, mastery-avoidance, performance-approach, performance-avoidance) and these orthogonal constructs have been found to influence students’ cognitive processes, affect, behaviour and perception in a situation (Ames & Archer, 1988; Anderman & Maehr, 1994; Dweck, 1996; Elliot & McGregor, 2001; Urdan & Midgley, 2003) and students’ self-regulated learning, namely their use of cognitive and regulatory strategies (Ablard & Lipschultz, 1998; Ee, Moore, & Atputhasamy, 2003; Kaplan & Midgley, 1997; Middleton & Midgley, 1997; Pajares, Britner, & Valiante, 2000; Patrick, Ryan, & Pintrich, 1999; Turner, Thorpe, & Meyer, 1998; Wolters, 2004; Wolters, Yu, & Pintrich, 1996). Constructivist pedagogy, with an emphasis on mastery of learning concepts, has much to offer the field of achievement goals (Blumenfeld, 1992), and in a reciprocal fashion research in the field of achievement goals informs constructivist theories of learning. In particular, there is a degree of convergence with regards to the empirical research on the pedagogical structures in the fields of achievement goals and constructivist-based pedagogy. Regarding achievement goals, the TARGET framework [T (tasks); A (authority-related aspects); R (recognition); G (grouping); E (evaluation); T (time)] classifies goal-related teacher practice with respect to various learning environment or pedagogical structures (Ames, 1992; Epstein, 1988; Maehr & Anderman, 1993; Midgley, 1993) and has been used by achievement goal researchers in order to ascertain the scope of classroom-level achievement goals in terms of pedagogical structures (Church, Elliot, & Gable, 2001; Greene, Miller, Crowson, Duke, & Akey, 2004; Patrick, Anderman, Ryan, Edelin, & Midgley, 2001; Turner, Meyer, Midgley, & Patrick, 2003). The Constructivist Learning Environment Survey
(CLES) has performed an analogous role in constructivism by quantifying the amount of constructivist-based pedagogical structures in science or math classrooms (Taylor & Fraser, 1991; Taylor, Fraser, & Fisher, 1997) on the basis of five types of structures or dimensions (personal relevance, student negotiation, shared control, critical voice, uncertainty). While this instrument can be used to ascertain the effectiveness of constructivist reforms (see Burnet, 2003) it may also be effective for quantifying science classrooms in terms of constructivist dimensions and thus enable valid statistical analyses encompassing achievement goals and self-regulated learning to be conducted. In turn this may enhance the generalisability of research findings since constructivist dimensions can be measured and compared from one class to the next even if no constructivist reforms are underway. However, there is no research on the use of this instrument in the context of contemporary achievement goal perspectives and hence one of the primary aims of the present research is to examine the relations between the constructs associated with achievement goals and self-regulated learning with those measured by the CLES in high school science classrooms.

An array of motivational beliefs accompanies achievement goal and self-regulated learning research. The present research incorporates the self-regulated learning model used by Pintrich and his colleagues, a model adapted from the expectancy-value theory of motivation (Eccles, 1983; Pintrich, 1989; Wigfield, 1994). According to this model, the motivational belief constructs of self-efficacy, test anxiety and intrinsic/task value, have some influence on the type of self-regulated learning processes a student adopts (Pintrich, 1989; Pintrich & De Groot, 1990; Wolters & Pintrich, 1998). Furthermore, these motivational beliefs may also influence achievement goals (Bandura, 1997; Elliot, 1999; Greene et al., 2004; Schunk, 1990).

As a result of these issues the present research addressed the following research question: What associations exist between high school science students’ perceptions of their learning environment characteristics, students’ personal achievement goals, motivational beliefs, and their self-regulated learning at the trait-level?

METHOD

Participants and procedure

A sample of 655 high school science students (333 males and 322 females) was assembled from ten different New South Wales State education system high schools serving the Sydney metropolitan area. Each school was co-educational, catered for students from years 7 to 12, randomly chosen from state high schools in the Sydney area and invited to participate. Seven schools were classified as regular (384 students) and served as the sample from the regular high school sub-population. The regular students’ sample comprised of 22 classes ranging in size from 7 to 28 students (mean class size = 17.5). Of this sample, 247 (139 males and 108 females) were in year 9, completing a general science curriculum and 137 (59 males and 78 females) were in year 11 completing a senior biology curriculum. Three schools were classified as selective (271 students) and served as the sample from the selective high school sub-population. The selective students’ sample comprised of 16 classes ranging in size from 8 to 29 students (mean class size = 16.9). Of this sample, 156 (88 males and 68 females) were in year 9, completing a general science curriculum and 115 (47 males and 68 females) were in year 11 completing a senior biology curriculum. For the regular students’ sample, students reported themselves as having the following ethnic backgrounds: Asian-Chinese (28, 7%), Asian-other (27, 7%), Caucasian (308, 80%), Filipino/Indonesian (14, 4%) and Indian/Sri Lankan (7, 2%). For the selective students’ sample, students reported themselves as having the following ethnic backgrounds: Asian-Chinese (79, 29%), Asian-other (23, 8%), Caucasian (129, 48%), Filipino/Indonesian (7, 3%) and Indian/Sri Lankan (33, 12%). Written parental permission was required for students to participate in the study. Students were informed that participation was voluntary and their responses would be kept confidential. Despite providing written parental permission, a small number of students declined to participate in the study.

Students were asked to complete three questionnaires (see Measures below) during the middle of the third term of the school year in one of their science lessons. By this time of the school year students’ relationships with class peers and class teacher were well established. The questionnaires were administered at the same time to each class by the researcher who instructed students to provide responses that focused on the particular science class and course they were participating in. Although the class teacher was present, he or she was not involved with any part of the administration procedure. Students were encouraged to ask questions regarding the clarification of any items. It took approximately 30 minutes for students to complete the questionnaires.

Measures

An outline of the scales and sample scale items associated with the questionnaires used to measure the classroom learning environment constructs are presented in Table 1. The scales and sample scale items used to measure the personal constructs are presented in Table 2.
ANALYSES

Preliminary analyses were conducted in order to ascertain the factorial structure, construct validity and distributional properties of the data. Essentially these analyses consisted of ascertaining the factorial structure of the questionnaires using exploratory factor analyses and confirmatory factor analyses, fitting one-factor congeneric measurement models to form the composite variables, and normalising the composite scale scores. Details of these procedures are reported elsewhere (Iverach, 2007). This process resulted in almost all composite scales having distributional properties close to being normal distributed with insignificant skewness and kurtosis. The results of the measurement properties attained from fitting one-factor congeneric models are presented in Tables 3 and 4. All of the composite scales exhibited satisfactory composite scale parameter results. The relevant goodness of fit indices of each composite scale are also presented in Tables 3 and 4; these were also satisfactory. The normalised composite scale scores were used in the structural equation modelling, the method used to analyse the simultaneous relationships between the explanatory and response variables.

Next, multilevel variance components models were constructed incorporating the subpopulation variables of age (junior or senior), gender and school type (regular or selective) as fixed effects explanatory variables with the residual variance of the construct under focus being partitioned into the level 1 (student-level) and level 2 (class-level) units with no other explanatory variables involved. The results of these analyses are reported in Tables 5 and 6. These results indicate only a slight degree of consensus when students report on their perception of the learning environment they experience and that most of the variance associated with the reporting of personal-based constructs is accounted for at the personal level and not to classroom-level differences. These findings are similar to others that have used hierarchical analyses of achievement goals (Anderman & Young, 1994; Ee et al., 2003; Wolters, 2004).

Structural equation modelling (SEM) was used to analyse the simultaneous relationships between the explanatory and response variables. Multilevel multiple regression analyses revealed most of the variance of the response variables, namely the four personal achievement goals and cognitive and regulatory strategy use, was attributed to the student-level (Iverach, 2007). Consequently, these results vindicated a single-level structural equation modelling approach for the data rather than a two-level structural equation modelling approach. In addressing the applicability of the structural equation modelling, the variances attributed to the classifier variables, namely gender, student age and student type, were removed. This was achieved by fitting a multivariate, multilevel model to the data using MLwiN 2.02 (Rowe, 2006; Rowe & Hill, 1998; Rowe & Rowe, 1999), with the classifier variables of gender, student age and student type assigned as fixed explanatory variables; the residuals of the other variables are allowed to be random thus yielding a variance-covariance matrix of these variables which can be used for structural equation modelling. Due to inadequate distributional properties, the learning environment variables of shared control and performance-avoidance goal structure were formed into dichotomous types and also declared as classifier variables. The results of fitting a multivariate, multilevel model to the data using MLwiN 2.02 are reported elsewhere (Iverach, 2007). The variance-covariance matrix obtained was used in the structural equation modelling. Note that the variance-covariance matrix of the variables in this case has been ‘purged’ (Rowe, 2006) of the variance attributed to the classifier variables thus increasing the generalisability of the structural equation modelling analyses. Therefore, the aim of the structural equation modelling approach used in the present research is to produce a model applicable to the ‘general’ high school science student: What are the interactions between the classroom learning environment and personal-level variables in high school science classrooms when the effects of classifier variables such as gender, student age, and student type are controlled for?
Table 1  
*Classroom Learning Environment Construct Scales and Sample Scale Items*

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Scale</th>
<th>Number of Scale Items</th>
<th>Sample Scale Items</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Personal relevance</td>
<td>6</td>
<td>I learn about the world outside of school.</td>
</tr>
<tr>
<td>The Constructivist Learning Environment Survey (CLES; Taylor et al., 1997)*</td>
<td>Uncertainty</td>
<td>6</td>
<td>I learn that science is influenced by people’s values and opinions.</td>
</tr>
<tr>
<td></td>
<td>Critical voice</td>
<td>6</td>
<td>It’s OK for me to question the way I’m being taught.</td>
</tr>
<tr>
<td></td>
<td>Shared control</td>
<td>6</td>
<td>I help the teacher to plan what I’m learning.</td>
</tr>
<tr>
<td></td>
<td>Student negotiation</td>
<td>6</td>
<td>I talk with other students about how to solve problems.</td>
</tr>
<tr>
<td></td>
<td>Mastery goal structure</td>
<td>5</td>
<td>My science teacher thinks mistakes are okay as long as we are learning.</td>
</tr>
<tr>
<td>Patterns of Adaptive Learning Survey (PALS; Kaplan, Gheen, &amp; Midgley, 2002; Midgley et al., 1997)*</td>
<td>Performance-approach goal structure</td>
<td>3</td>
<td>My science teacher points out those students who get good grades as an example to all of us.</td>
</tr>
<tr>
<td></td>
<td>Performance-avoidance goal structure</td>
<td>4</td>
<td>My science teacher says that showing others that we are not bad in science should be our goal.</td>
</tr>
<tr>
<td>The Metacognitive Orientation Learning Environment Scale-Science (MOLES-S; Thomas, 2003)*</td>
<td>Classroom metacognitive structure</td>
<td>5</td>
<td>Students are asked by the teacher to think about how they learn science.</td>
</tr>
</tbody>
</table>

*Note.* *Students indicated their responses on a five-point Likert scale ranging from 1 (almost never) to 5 (almost always).*
Table 2
*Personal Construct Scales and Sample Scale Items*

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Scale</th>
<th>Number of Scale Items</th>
<th>Sample Scale Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Achievement Goals Questionnaire (Elliot &amp; Church (1997)*</td>
<td>Mastery-approach</td>
<td>6</td>
<td>It is important for me to understand what is being taught.</td>
</tr>
<tr>
<td></td>
<td>Mastery-avoidance</td>
<td>6</td>
<td>I focus on not making any mistakes at all during my learning in this class.</td>
</tr>
<tr>
<td></td>
<td>Performance-approach</td>
<td>6</td>
<td>It is important for me to do better than the other students.</td>
</tr>
<tr>
<td></td>
<td>Performance-avoidance</td>
<td>6</td>
<td>I just want to avoid doing poorly, compared to others, in this class.</td>
</tr>
<tr>
<td>Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich, Smith, Garcia, &amp; McKeachie, 1991)*</td>
<td>Intrinsic value</td>
<td>9</td>
<td>I prefer class work that is challenging so I can learn new things.</td>
</tr>
<tr>
<td></td>
<td>Test anxiety</td>
<td>4</td>
<td>I am so nervous during a test that I cannot remember the facts that I have learned.</td>
</tr>
<tr>
<td></td>
<td>Self-efficacy</td>
<td>9</td>
<td>I am certain that I can understand the ideas taught in this class.</td>
</tr>
<tr>
<td>Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1991)*</td>
<td>Cognitive strategy use</td>
<td>13</td>
<td>When I study for a test, I try to put together the information from the class and from the textbook.</td>
</tr>
<tr>
<td></td>
<td>Regulatory strategy use</td>
<td>9</td>
<td>I ask myself questions to make sure I know the material I have been studying.</td>
</tr>
</tbody>
</table>

*Note.* "Students indicated their responses on a seven-point Likert scale ranging from 1 (not at all true of me) to 7 (very true of me); 'a six-item scale that assessed students’ mastery-avoidance goal was added to Elliot and Church’s (1997) questionnaire which was developed for the trichotomous goal model."
### Table 3

**Classroom Learning Environment Constructs: One-Factor Congeneric Model Fit Indices and Composite Scale Parameters**

<table>
<thead>
<tr>
<th>Composite Variable</th>
<th>No. of items</th>
<th>$\chi^2$</th>
<th>$df$</th>
<th>$p$</th>
<th>GFI</th>
<th>AGFI</th>
<th>RMR</th>
<th>RMSEA</th>
<th>$r_c$</th>
<th>$\hat{\lambda}_c$</th>
<th>$\hat{\Theta}_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal relevance</td>
<td>6</td>
<td>5.402</td>
<td>5</td>
<td>.369</td>
<td>.999</td>
<td>.995</td>
<td>.0185</td>
<td>.0111</td>
<td>.767</td>
<td>.876</td>
<td>.233</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>6</td>
<td>5.307</td>
<td>5</td>
<td>.380</td>
<td>.990</td>
<td>.995</td>
<td>.0203</td>
<td>.0097</td>
<td>.704</td>
<td>.839</td>
<td>.296</td>
</tr>
<tr>
<td>Critical voice</td>
<td>5</td>
<td>2.744</td>
<td>2</td>
<td>.254</td>
<td>.999</td>
<td>.996</td>
<td>.0128</td>
<td>.0238</td>
<td>.870</td>
<td>.913</td>
<td>.125</td>
</tr>
<tr>
<td>Shared control</td>
<td>6</td>
<td>14.515</td>
<td>7</td>
<td>.043</td>
<td>.997</td>
<td>.992</td>
<td>.0285</td>
<td>.0405</td>
<td>.937</td>
<td>.922</td>
<td>.057</td>
</tr>
<tr>
<td>Student negotiation</td>
<td>5</td>
<td>3.687</td>
<td>2</td>
<td>.158</td>
<td>.999</td>
<td>.995</td>
<td>.0103</td>
<td>.0359</td>
<td>.907</td>
<td>.931</td>
<td>.089</td>
</tr>
<tr>
<td>Mastery goal structure</td>
<td>5</td>
<td>1.335</td>
<td>2</td>
<td>.513</td>
<td>1.000</td>
<td>.998</td>
<td>.0064</td>
<td>.0000</td>
<td>.882</td>
<td>.919</td>
<td>.113</td>
</tr>
<tr>
<td>Performance-approach goal</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.782</td>
<td>.862</td>
<td>.207</td>
</tr>
<tr>
<td>Performance-avoidance goal</td>
<td>4</td>
<td>.264</td>
<td>1</td>
<td>.608</td>
<td>1.000</td>
<td>.999</td>
<td>.0030</td>
<td>.0000</td>
<td>.821</td>
<td>.852</td>
<td>.158</td>
</tr>
<tr>
<td>Classroom metacognitive structure</td>
<td>5</td>
<td>5.701</td>
<td>2</td>
<td>.058</td>
<td>.999</td>
<td>.990</td>
<td>.0182</td>
<td>.0532</td>
<td>.896</td>
<td>.934</td>
<td>.101</td>
</tr>
</tbody>
</table>

**Note.** $\chi^2$ = minimum fit function chi-square; $df$ = degrees of freedom; $p$ = significance of difference between the observed and estimated population covariance matrices on the basis of the minimum fit function $\chi^2$; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; RMR = root mean square residual; RMSEA = root mean square error of approximation; $r_c$ = composite scale reliability coefficient; $\hat{\lambda}_c$ = variance estimate of items attributed to the composite variable; $\hat{\Theta}_c$ = variance estimate of items attributed to measurement error.
<table>
<thead>
<tr>
<th>Composite Variable</th>
<th>No. of items</th>
<th>$\chi^2$</th>
<th>df</th>
<th>$p$</th>
<th>GFI</th>
<th>AGFI</th>
<th>RMR</th>
<th>RMSEA</th>
<th>$r_c$</th>
<th>$\hat{\lambda}_c$</th>
<th>$\hat{\theta}_c$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mastery-approach</td>
<td>6</td>
<td>5.707</td>
<td>7</td>
<td>.574</td>
<td>.999</td>
<td>.997</td>
<td>.0149</td>
<td>.0000</td>
<td>.871</td>
<td>.928</td>
<td>.127</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>4</td>
<td>.000</td>
<td>0</td>
<td>1.000</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>.718</td>
<td>.845</td>
<td>.280</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>4</td>
<td>.057</td>
<td>1</td>
<td>.812</td>
<td>1.000</td>
<td>1.000</td>
<td>.0013</td>
<td>.0000</td>
<td>.898</td>
<td>.930</td>
<td>.098</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>6</td>
<td>4.502</td>
<td>5</td>
<td>.480</td>
<td>.999</td>
<td>.996</td>
<td>.0151</td>
<td>.0000</td>
<td>.753</td>
<td>.867</td>
<td>.247</td>
</tr>
<tr>
<td>Intrinsic value</td>
<td>4</td>
<td>.675</td>
<td>1</td>
<td>.411</td>
<td>1.000</td>
<td>.998</td>
<td>.0040</td>
<td>.0000</td>
<td>.878</td>
<td>.926</td>
<td>.119</td>
</tr>
<tr>
<td>Test anxiety</td>
<td>4</td>
<td>.427</td>
<td>1</td>
<td>.513</td>
<td>1.000</td>
<td>.999</td>
<td>.0047</td>
<td>.0000</td>
<td>.834</td>
<td>.900</td>
<td>.161</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>8</td>
<td>23.81</td>
<td>15</td>
<td>.068</td>
<td>.997</td>
<td>.992</td>
<td>.0344</td>
<td>.0300</td>
<td>.902</td>
<td>.950</td>
<td>.098</td>
</tr>
<tr>
<td>Regulatory strategy use</td>
<td>11</td>
<td>52.04</td>
<td>37</td>
<td>.052</td>
<td>.994</td>
<td>.989</td>
<td>.0489</td>
<td>.0249</td>
<td>.906</td>
<td>.950</td>
<td>.094</td>
</tr>
<tr>
<td>Cognitive strategy use</td>
<td>6</td>
<td>11.00</td>
<td>7</td>
<td>.140</td>
<td>.998</td>
<td>.993</td>
<td>.0233</td>
<td>.0295</td>
<td>.829</td>
<td>.906</td>
<td>.169</td>
</tr>
</tbody>
</table>

*Note. $\chi^2 =$ minimum fit function chi-square; $df =$ degrees of freedom; $p =$ significance of difference between the observed and estimated population covariance matrices on the basis of the minimum fit function $\chi^2$; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; RMR = root mean square residual; RMSEA = root mean square error of approximation; $r_c =$ composite scale reliability coefficient; $\hat{\lambda}_c =$ variance estimate of items attributed to the composite variable; $\hat{\theta}_c =$ variance estimate of items attributed to measurement error.*
### Table 5

*Classroom Learning Environment Constructs: Variance Components Models with Subpopulation Classifier Variables*

<table>
<thead>
<tr>
<th>Construct</th>
<th>Fixed Part</th>
<th>Random Part (Residual variance)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercepts</td>
<td>Age(^a) Gender(^b) Student type(^c) Classroom level Student level</td>
</tr>
<tr>
<td></td>
<td>$\beta_{0y}$ (s.e.) $\beta_{1}$ (s.e.) $\beta_{2}$ (s.e.) $\beta_{3}$ (s.e.)</td>
<td>$\sigma_y^2$ (s.e.)</td>
</tr>
<tr>
<td>Personal relevance</td>
<td>.065 (.137) -.297 (.144) .100 (.077)* .044 (.142)*</td>
<td>.127 (.042) 12.8</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>.306 (.102) -.497 (.102) -.076 (.078)* .085 (.101)*</td>
<td>.035 (.021)* 3.7</td>
</tr>
<tr>
<td>Critical voice</td>
<td>.056 (.142) -.180 (.150)* .096 (.074)* -.072 (.148)*</td>
<td>.147 (.046) 15.5</td>
</tr>
<tr>
<td>Student negotiation</td>
<td>-.201 (.100) -.186 (.100)* .377 (.076) .257 (.099)</td>
<td>.034 (.020)* 3.8</td>
</tr>
<tr>
<td>Mastery goal structure</td>
<td>.090 (.200) -.386 (.218) .171 (.064) -.074 (.216)*</td>
<td>.387 (.098) 39.3</td>
</tr>
<tr>
<td>Performance-approach goal structure</td>
<td>-.062 (.136) .156 (.143)* -.007 (.074)* -.076 (.136)*</td>
<td>.130 (.042) 13.9</td>
</tr>
<tr>
<td>Metacognitive structure</td>
<td>-.014 (.145) -.219 (.153)* .129 (.075)* .109 (.152)*</td>
<td>.156 (.048) 16.0</td>
</tr>
</tbody>
</table>

**Note.** $n = 623$; \(^a\)Age is coded 0 = senior and 1 = junior; \(^b\)Gender is coded 0 = male and 1 = female; \(^c\)Student type is coded 0 = regular and 1 = selective; \(^d\)All results significant at $p < .05$ (two-tailed test) except *not significant at $p < .05$ (two-tailed test).
Table 6

Personal Constructs: Variance Components Models with Subpopulation Classifier Variables

<table>
<thead>
<tr>
<th>Construct</th>
<th>Fixed Part</th>
<th>Random Part (Residual variance)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intercepts</td>
<td>Age^a</td>
</tr>
<tr>
<td></td>
<td>β_{0ij} (s.e.)</td>
<td>β_1 (s.e.)^d</td>
</tr>
<tr>
<td>Mastery-approach</td>
<td>.250 (.098)</td>
<td>-3.87 (.096)</td>
</tr>
<tr>
<td>Mastery-avoidance</td>
<td>.229 (.086)</td>
<td>.017 (.081)*</td>
</tr>
<tr>
<td>Performance-approach</td>
<td>.235 (.101)</td>
<td>-1.70 (.100)*</td>
</tr>
<tr>
<td>Performance-avoidance</td>
<td>-.083 (.087)</td>
<td>-.065 (.083)*</td>
</tr>
<tr>
<td>Intrinsic value</td>
<td>.264 (.113)</td>
<td>-.428 (.115)</td>
</tr>
<tr>
<td>Test anxiety</td>
<td>-.070 (.085)</td>
<td>-.148 (.080)*</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>.249 (.087)</td>
<td>-.052 (.082)*</td>
</tr>
<tr>
<td>Regulatory strategy use</td>
<td>-.054 (.093)</td>
<td>-.217 (.090)</td>
</tr>
<tr>
<td>Cognitive strategy use</td>
<td>-.113 (.086)</td>
<td>-.137 (.081)*</td>
</tr>
</tbody>
</table>

Note. n = 623; ^a Age is coded 0 = senior and 1 = junior; ^b Gender is coded 0 = male and 1 = female; ^c Student type is coded 0 = regular and 1 = selective; ^d All results significant at p < .05 (two-tailed test) except *not significant at p < .05 (two-tailed test).
RESULTS

The theoretically-based hypothesised self-regulated learning structural equation model is presented in Figure 1. However, this initial model provided an unsatisfactory fit of the data with $\chi^2 = 593.2$ ($df = 54$, $p < .001$), RMSEA $= 0.1260$, SRMR $= 0.0801$, GFI $= 0.897$, AGFI $= 0.741$, CFI $= 0.906$, and NFI $= 0.899$. Revision of the initial model and the subsequent modelling was based upon the results obtained from the multilevel multiple regressions reported elsewhere (Iverach, 2007) and by investigating the suggested modification indices within substantive grounds using the maximum likelihood method of estimation via LISREL 8.72. This approach resulted in the final self-regulated learning structural equation model providing a satisfactory fit of the data with $\chi^2 = 48.17$ ($df = 40$, $p = .176$), RMSEA $= 0.0182$, SRMR $= 0.0156$, GFI $= 0.990$, AGFI $= 0.967$, CFI $= 0.999$, and NFI $= 0.992$. Using generalised least squares used as the estimation method also revealed the model to satisfactorily fit the data with $\chi^2 = 45.82$ ($df = 40$, $p = .244$), RMSEA $= 0.0225$, SRMR $= 0.0171$, GFI $= 0.991$, AGFI $= 0.969$, CFI $= 0.992$, and NFI $= 0.949$.

For clarity, the final model is presented over three figures (Figures 2 to 4). The standardised direct effects path model for the classroom learning environment variables is displayed in Figure 2. The constructivist pedagogical dimensions had significant relations with personal achievement goals and self-regulated learning. Of these dimensions, personal relevance ($\gamma = 0.133$, $p < .01$) and student negotiation ($\gamma = 0.159$, $p < .001$) were significant positive predictors of mastery-approach while uncertainty was a positive predictor of performance-avoidance ($\gamma = 0.141$, $p < .01$). Personal relevance was also a positive predictor of intrinsic value ($\gamma = 0.305$, $p < .001$). There was also some support for the hypothesised relations for the classroom goal and metacognitive structures. Although the mastery goal structure was not a significant predictor of mastery-approach ($\gamma = 0.009$), it had positive relations with intrinsic value ($\gamma = 0.257$, $p < .001$) and negative relations with performance-approach ($\gamma = -0.121$, $p < .001$). Interestingly, the performance-approach goal structure had no significant relations with the performance-related achievement goals. Three of the classroom learning environment variables had significant impact on students’ self-regulated learning. Student negotiation was a positive influence on regulatory strategy use ($\gamma = 0.083$, $p < .01$) as was the metacognitive goal structure ($\gamma = 0.139$, $p < .001$). The mastery goal structure was a significant negative predictor of regulatory strategy use ($\gamma = -0.119$, $p < .001$).

The standardised direct effects path model for the motivational belief variables is displayed in Figure 3. Intrinsic value was a positive predictor of master-approach ($\beta = 0.578$, $p < .001$); it also had direct negative relations with mastery-avoidance ($\beta = -0.035$) and performance-avoidance ($\beta = -0.103$), although these negative relations were not statistically significant. Self-efficacy was an influential explanatory variable for personal achievement goals and self-regulated learning. Self-efficacy was a significant positive predictor of mastery-avoidance ($\gamma = 0.230$, $p < .001$), performance-approach ($\gamma = 0.400$, $p < .001$), and performance-avoidance ($\gamma = 0.368$, $p < .001$); it had non-significant relations with mastery-approach ($\gamma = 0.051$). Self-efficacy also positively predicted intrinsic value ($\gamma = 0.440$, $p < .001$) and regulatory strategy use ($\gamma = 0.414$, $p < .001$), and was a non-significant negative predictor of cognitive strategy use ($\gamma = -0.061$). Test anxiety was a significant positive predictor of performance-avoidance ($\gamma = 0.598$, $p < .001$) and had negative relations with mastery-avoidance ($\gamma = -0.122$) and performance-approach ($\gamma = -0.062$), although these were statistically non-significant. Test anxiety also negatively predicted regulatory strategy use ($\gamma = -0.162$, $p < .01$) in contrast to its relation to cognitive strategy use ($\gamma = 0.171$, $p < .001$), for which it was a positive predictor.

The standardised direct effects path model for the personal achievement goals and self-regulated learning variables is displayed in Figure 4. Regulatory strategy use was positively predicted by mastery-approach ($\beta = 0.422$, $p < .001$) and performance-avoidance ($\beta = 0.507$, $p < .001$). Negative predictors of regulatory strategy use included mastery-avoidance ($\beta = -0.311$, $p < .001$) and performance-approach ($\beta = -0.158$, $p < .05$). The only significant predictor of cognitive strategy use was regulatory strategy use ($\beta = 0.878$, $p < .001$). The rather large amount of covariance between cognitive and regulatory strategy use indicated that these two variables were highly related. A significant amount of covariance was found to exist between performance-avoidance with the other achievement goals. Performance-avoidance was found to positively predict mastery-approach ($\beta = 0.214$, $p < .001$), mastery-avoidance ($\beta = 0.714$, $p < .001$) and performance-approach ($\beta = 0.536$, $p < .001$). These results indicate that most students endure some form of avoidance with respect to external competence-related issues and this is irrespective of students’ other achievement goal orientations. The variances of the endogenous variables explained by the revised model (Figures 3 and 4) were as follows: mastery-approach (68%), mastery-avoidance (55%) performance-approach (60%), performance-avoidance (53%), intrinsic value (59%), cognitive strategy use (72%), and regulatory strategy use (63%). These totals were considerably more than those obtained using multilevel multiple regression analyses for each variable (see Iverach, 2007). The standardised direct, indirect and total effects for the revised self-regulated learning structural equation model using maximum
Figure 1. Hypothesised self-regulated learning structural equation model. The exogenous variables are symbolised as: personal relevance (perrel); uncertainty (uncert); critical voice (critv); student negotiation (studneg); mastery goal structure (clmast); performance-approach goal structure (clpap); metacognitive structure (clmeta); self-efficacy (eff); test anxiety (testa). The endogenous variables are symbolised as: mastery-approach (map); mastery-avoidance (mav); performance-approach (pap); performance-avoidance (pav); intrinsic value (intrv); cognitive strategy use (cog); regulatory strategy use (reg).
Figure 2. Revised structural equation model displaying the standardised direct effects for the classroom learning environment variables. The exogenous variables are symbolised as: personal relevance (perrel); uncertainty (uncert); critical voice (critv); student negotiation (studneg); mastery goal structure (clmast); performance-approach goal structure (clpap); metacognitive structure (clmeta); self-efficacy (eff); test anxiety (testa). The endogenous variables are symbolised as: mastery-approach (map); mastery-avoidance (mav); performance-approach (pap); performance-avoidance (pav); intrinsic value (intrv); cognitive strategy use (cog); regulatory strategy use (reg). * p < .05. ** p < .01. *** p < .001.
Figure 3. Revised structural equation model displaying the standardised direct effects for the motivational belief variables. The exogenous variables are symbolised as: personal relevance (perrel); uncertainty (uncert); critical voice (critv); student negotiation (studneg); mastery goal structure (clmast); performance-approach goal structure (clpap); metacognitive structure (clmeta); self-efficacy (eff); test anxiety (testa). The endogenous variables are symbolised as: mastery-approach (map); mastery-avoidance (mav); performance-approach (pap); performance-avoidance (pav); intrinsic value (intrv); cognitive strategy use (cog); regulatory strategy use (reg). * $p < .05$. ** $p < .01$. *** $p < .001$. 

$R^2 = .585$

intrv $\eta_1$

unc $\xi_2$

eff $\xi_3$

cog $\eta_7$

testa $\xi_4$

perrel $\xi_1$

studneg $\xi_5$

critv $\xi_6$

clpap $\xi_2$

clmeta $\xi_3$

clmast $\xi_4$

map $\eta_1$

mav $\eta_2$

pap $\eta_3$

pav $\eta_4$

reg $\eta_6$

pap $\eta_3$

cog $\eta_7$

testa $\xi_4$

intrv $\eta_1$

$-.103$

$-.061$

$.171***$

$-.162*$

$-.062$

$.051$

$.230***$

$.400***$

$.368***$

$.440***$

$.578***$

$.585$

$.415***$
Figure 4. Revised structural equation model displaying the standardised direct effects for the personal achievement goals and self-regulated learning variables. The exogenous variables are symbolised as: personal relevance (perrel); uncertainty (uncert); critical voice (critv); student negotiation (studneg); mastery goal structure (clmast); performance-approach goal structure (clpap); metacognitive structure (clmeta); self-efficacy (eff); test anxiety (testa). The endogenous variables are symbolised as: mastery-approach (map); mastery-avoidance (mav); performance-approach (pap); performance-avoidance (pav); intrinsic value (intrv); cognitive strategy use (cog); regulatory strategy use (reg). * $p < .05$. ** $p < .01$. *** $p < .001$. 
likelihood as the estimation method are reported elsewhere (Iverach, 2007). Almost identical results were obtained using generalised least squares as the estimation method (Iverach, 2007).

DISCUSSION

This study contributed to research addressed by the fields of constructivist pedagogy, achievement motivation and self-regulated learning by adopting a multidisciplinary approach to studying the interactions of the constructs associated with each field in the context of the high school science classroom. By incorporating students’ perceptions of the constructivist pedagogical nature of their science classroom with achievement goal theory, motivational belief and self-regulated learning constructs, the present study attempted to extend the understanding of the nature of teaching and learning in the high school science classroom from an integrated social cognitive perspective.

The first focus of discussion concerns the results attained for the associations between the environmental and personal predictors of achievement goals. The constructivist pedagogy dimensions of personal relevance and student negotiation were positive predictors of mastery-approach goals for high school science students. Thus, students who perceive their science classroom as having an emphasis on personal relevance and fostering the negotiation of their understanding will tend to adopt mastery-approach goals. It should be kept in mind that this study was correlational in nature and any causal paths discussed are inferred only. To prove causality, experimental-based or longitudinal studies need to be conducted. For example, although the personal relevance and student negotiation features of the science classroom are presented as significant environmental predictors of the mastery-goal approach in the present research findings it could well be that students who report higher mastery-approach goal orientations perceive their classroom as higher in personal relevance and student negotiation than students who report lower mastery-goal approach orientations. Nevertheless, the results show the importance of these two constructivist pedagogical features for the adoption of mastery-goal approaches. This has implications towards the generalisability of these findings: science teachers will take a step towards procuring mastery-approach goals in their students if they place an emphasis on personal relevance and the student negotiation of learning.

The results of the present research found that the motivational belief of intrinsic value may have mediated the impact of the mastery goal structure on students’ mastery-approach, with both paths having positive relations. Hence students’ intrinsic value will increase with an increase in the classroom’s mastery goal structure; an increase in intrinsic value, in turn, increases the mastery-approach of science students. This result indicates that the high school science teacher who actively creates an environment with a focus upon students’ learning may have an indirect positive influence upon students’ mastery-approach goals.

Of the personal factors, intrinsic value was a highly significant direct positive predictor of the mastery-approach goal, although it may have mediated the relations between mastery goal structure and mastery-approach. This result was expected at the personal level since according to the hierarchical model of achievement goals (Elliot, 1999; Elliot & Church, 1997; Elliot & Harackiewicz, 1996; Elliot & McGregor, 2001) mastery-approach is associated with the need to achieve in learning and this would stem from having some form of intrinsic value associated with the task or learning experience. An emphasis on personal relevance by the teacher may be of use in fostering greater intrinsic value in students and hence a mastery-approach to learning; this view is supported by the positive relations between personal relevance and intrinsic value in the structural equation model (Figure 2). Prior research has shown self-efficacy to be a positive predictor of mastery-approach goals (Kaplan & Maehr, 1999; Kaplan & Midgley, 1999; Middleton, Kaplan, & Midgley, 2004; Middleton, & Midgley, 1997; Patrick et al., 1999; Roeser, Midgley, & Urdan, 1996; Skaalvik, 1997). However, in the present research this was the case only in the regression analyses (Iverach, 2007). According to the 2 X 2 achievement goals model of Elliot and colleagues (e.g., Elliot & McGregor, 2001), efficacious students tend to persist with tasks since they believe that they are capable of accomplishing the task. Furthermore, the relationship between self-efficacy and mastery is volitional in nature, with students developing greater efficacy as they achieve mastery of the task (Schunk, 1990, 1996; Schunk & Ertmer, 1999). This theory may not apply to students who are already highly efficacious, such as the selective students who made up 41% of the sample, with respect to their task mastery skills. Perhaps also the mastery-approach goal of high school science students is more dependent on the intrinsic value of the task rather than on the level of process-type skills and efficacy they perceive they have. A positive relationship was also found between performance-avoidance and mastery-approach goals using SEM. The relationship between performance-avoidance and mastery-approach was, although significant, small ($\beta = 0.214$, $p < .001$) compared with the relations between performance-avoidance and the other achievement goals: mastery-avoidance ($\beta = 0.714$, $p < .001$) and performance-approach ($\beta = 0.536$, $p < .001$). This result could be explained by high school students being almost as concerned about their own learning accomplishment as they are about their fear of failing in front of others and these two concerns are somewhat related, albeit distally. Concerns about failing to learn and failing to perform in the science classroom...
would be expected to be more closely related than concerns about achieving learning and fear of failing and thereby explains why the association between performance-avoidance and mastery-avoidance is higher than that obtained for performance-avoidance with mastery-approach. Similarly, the relations between the need to perform normatively and fear of failing would be expected to be more proximal than achieving learning and fear of failing and thus the effect for performance-avoidance and performance-approach is higher than for performance-avoidance with mastery-approach. For example, according to the hierarchical theory on achievement goals of Elliot and his colleagues (Church et al., 2001; Elliot, 1999; Elliot & Church, 1997; Elliot & McGregor, 2001), the performance-approach goal has the need for both achieving and not failing.

For mastery-avoidance, the results of the SEM analyses indicated that only self-efficacy and performance-avoidance were significant positive predictors of mastery-avoidance. These results support the prevailing theory on mastery-avoidance goals which suggests that such goals are related to students that have high expectations towards their learning goals (Elliot, 1999; Elliot & McGregor, 2001; Pintrich, 2000). It would be expected that such students would have high feelings of self-efficacy and therefore have high levels of personal learning expectations. However, the present research has also revealed that such students are prone to performance-avoidance, implying that avoidance inclinations may be omnibus in character.

Just one significant relationship was found regarding the associations between the classroom environmental factors with performance-approach goals, with the mastery goal structure being a negative predictor. Thus, an emphasis on learning by the teacher reduces the performance-approach tendencies of high school science students. Although there is research showing that a classroom emphasis on performance encourages performance-approach and avoidance goals (Midgley & Urdan, 2001; Wolters, 2004), there is also research that has found inconsistent relations between performance goal structures and personal performance goals. For example, Anderman and Midgley (1997) found only grade 6 females’ performance achievement goals to increase with perceptions of increases in performance goal structure. Young’s (1997) study showed only positive relations between performance goal structure and performance-approach goals for English classes and not for math classes. Nolen (2003) found no relations between an ability-meritocracy goal structure (similar to performance-approach goal structure) toward the personal performance-approach goal for ninth-grade high school science students. In the present research, the performance-goal structure had no bearing upon students’ personal goals. Research has shown, in the main, that mastery-approach goals are more sensitive to the influence of classroom goal structures than performance-based goals (Anderman & Midgley, 1997; Ee et al., 2003; Nolen, 2003; Urdan & Midgley, 2003; Young, 1997). This finding was weakly supported in the present research, with only the mastery-approach goal affected by more than one of the students’ perceptions of the classroom learning environment features, namely the constructivist pedagogy dimensions of personal relevance and student negotiation. Apart from the mastery goal structure being a negative predictor of performance-approach goals, the traditional classroom features of mastery goal and performance goal structures did not associate with personal goals after controlling for the effects of the constructivist pedagogy dimensions amongst other variables. Thus, it seems that constructivist pedagogy is a considerable influence upon the personal mastery-approach goals of high school science students. Self-efficacy was a positive predictor of performance-approach goals. This is to be expected, for students who are more efficacious would more likely pursue performance-associated goals.

Of the environmental predictors, only uncertainty was found to positively predict performance-avoidance. This result is puzzling since the uncertainty construct measures students’ perceptions of their classroom in respect to the nature of science and was hypothesised to have null relations with the performance-based goals. As for mastery-avoidance and performance-approach, the personal factors of self-efficacy and test anxiety were both positive predictors of performance-avoidance in the SEM analyses. Having test anxiety as a positive predictor of performance-avoidance is expected as this achievement goal is grounded in concerns with failing (Elliot, 1999). The self-efficacy finding is at odds with other research which has found negative relations between self-efficacy and performance-avoidance goals (Middleton & Midgley, 1997; Skaalvik, 1997) and between perceived ability and performance-avoidance goals (Church et al., 2001; Elliot & Church, 1997; Pajares et al., 2000). It is expected that students who are highly efficacious or have high ability perceptions would tend not to avoid performance-based endeavours in the classroom.

The second focus of discussion regarding the research question concerns the results attained for the associations between the environmental and personal predictors of self-regulated learning for high school science students, namely the use of cognitive and regulatory strategies. One limitation of the self-regulated learning items used in the present research concerns the amount of out-of-class references the items contain. After factor analysis and confirmatory factor analysis, the items representing both cognitive and regulatory strategies from the Motivated Strategies for Learning Questionnaire tended to focus on students’ studying habits out of class rather than their in-class self-regulated learning. This limitation may be addressed by asking students to report on their self-regulated learning within specified learning contexts (e.g., Iverach, 2007). Thus, students’ use of cognitive and regulatory strategies may have limited valid relations with classroom environmental parameters such as student negotiation and mastery goal structure and thereby cause invalid relations to occur between classroom-associated variables and self-regulated learning. The mastery goal structure, for example, was a
negative predictor of regulatory strategy use, which is contrary to that hypothesised. Despite these limitations, there was substantial support for the hypothesised positive influence of the metacognitive goal structure upon students’ reporting of their self-regulated learning - the metacognitive goal structure was a significant positive predictor of regulatory strategy use. Consequently, teachers that attempt to make their students think about the way they are learning science foster greater use of regulatory strategies by students.

The study found several personal factors to influence self-regulated learning. There were positive associations between mastery-approach and regulatory strategy use. These results support the normative goal model, which contends that a mastery goal orientation fosters the use of self-regulatory strategies such as monitoring with respect to one’s internal standards and regulating progress in attempting to find effective strategies that bring about learning and understanding (Pintrich, 2000).

This study was one of the first to investigate the consequences of the mastery-avoidance goal in terms of self-regulated learning. The results obtained show that mastery-avoidance has some negative effects towards the use of self-regulated learning, with negative associations between mastery-avoidance and regulatory strategy use. According to Elliot’s & McGregor’s (2001) seminal work on mastery-avoidance, mastery-avoidance is associated with disorganisation, test anxiety, worry, and emotionality issues. This study supplements that work in finding that students who tend towards mastery-avoidance also report themselves as using less self-regulated learning in terms of regulatory strategy use. Hence there is some support here for the negative connotations of internal-referenced avoidance tendency.

On the basis of previous research, it was hypothesised that performance-approach goals would have null relations with self-regulated learning (Bandalos, Finney, & Geske, 2003; Ee et al., 2003; Elliot & McGregor, 2001; Elliot, McGregor, & Gable, 1999; Ford, Smith, Weissbein, Gully, & Salas, 1998; Greene & Miller, 1996; Kaplan & Midgley, 1997; Middleton & Midgley, 1997; Neber & Schommer-Aikins, 2002; Niemivirta, 1997; Pajares et al, 2000; Turner et al., 1998; Wolters, 2004). However, the SEM analyses used in the present research found performance-approach to be a negative predictor of regulatory strategy use. Hence students who report they pursue ability or external standards in the classroom tended to report they use less regulatory strategies. This result may be partly explained by examining the intent of the items used for the regulatory strategy use and performance-approach constructs. The performance-approach goal items reflected the within-class-time aspirations of students (“I am trying to show that I have better ability than others in this class”) and are more ecologically attuned to performance-related issues within the classroom. In contrast, those items used to represent regulatory strategy use tended to reflect out-of-class experiences. Consequently, the regulatory strategy use items are indicative of metacognitive learning approaches students associate with outside the classroom rather than demonstrations of normative competence within the classroom. Nevertheless, this result supports the traditional achievement goals theory which contends that performance-based motivation is associated with negative patterns of learning processes such as surface processing. According to traditional goals theory, performance-focused students make judgements about their progress that are mediated by perceptions of effort and ability and utilising surface processing approaches to learning require minimal amounts of effort (Ames & Archer, 1988; Dweck & Elliott, 1983; Dweck & Legget, 1988; Elliott & Dweck, 1988). As a consequence of this theory, adoption of a performance goal construes negative learning processes such as adopting superficial learning strategies since these require minimisation of effort and therefore ability-based perceptions of competence are not threatened. On the other hand, according to this theory, mastery goal-focused students attribute failure not to ability but to effort; they simply increase their effort in the face of failure. In other words, there was no support for the adaptive nature of the performance-approach goal in the present research.

Although performance-avoidance was hypothesised as having null relations with self-regulated learning, the present study found it to be a positive predictor of regulatory strategy use. Similar to that described above for performance-approach goals, the intent of the performance-avoidance items was classroom-situated rather than at a generic, trait-level outside-classroom-reference, which is what the bulk of the regulatory strategy use items were based upon. Future studies would need to consider this important distinction when examining the relations between achievement goals and self-regulated learning. In consideration of the results found in the present research, it seems that the performance-avoidance goal represented fear of failing, as expected from Elliot’s (1999) hierarchical theory of achievement goals. Fear of failing, however, in terms of failing to meet external or normative standards of acceptance, had some adaptive qualities associated with it. In the current case, it was found that performance-avoidance had positive associations with regulatory strategy use and mastery-approach. These results indicate that the fear of failing with respect to external standards may be a motivational stimulus for students to self-regulate adaptively outside the classroom - students will avoid failing if they prepare for class. The results also reflect that the fear of failing is orthogonal with respect to the other personal achievement goals. That is, the fear of failing is an orientation affiliated with the concern of failing to meet external competence expectations and this orientation may be coupled with other classroom learning environment concerns such as the concerns of accomplishing learning and achieving performance-based outcomes as alluded to above. Thus, students may have high orientations in all these types of concerns. Indeed the results of the present research have spawned a form of “concern” hypothesis in that the concern of students may be an
important antecedent of achievement goals. Students that are concerned about their learning, concerned about their performance and concerned about failing to perform in exams may report to have high achievement goal orientations in mastery-approach, performance-approach and performance-avoidance respectively; those who are not concerned about these matters will tend to report low achievement goal orientations. This model explains the various associations found in the present research amongst the achievement goals and their consequences.

There was support for the hypothesised relations between the motivational beliefs and the use of self-regulated learning strategies. As hypothesised, high school science students reported that the use of regulatory strategies was positively influenced by feelings of efficacy. This is in accord with theories of SRL which contend that efficacious students tend to utilise self-regulatory learning mechanisms such as metacognitive strategies (Skunk \& Ertmer, 1999; Zimmerman, 1989) and with other research that has found self-efficacy to positively predict the use of regulatory strategies (Ames \& Archer, 1988; Kaplan \& Midgley, 1997; Neber \& Schommer-Aikins, 2002; Wolters \& Pintrich, 1998). Students that are efficacious have confidence in their ability and tend to persist in the face of difficulty, believing in effort attributions to success. Test anxiety was found to be a negative predictor of regulatory strategy use, as hypothesised, and a positive predictor of cognitive strategy use, a result contrary to that hypothesised. These results, however, support those obtained by Wolters and Pintrich (1998), who found students who reported higher levels of test anxiety to maintain their use of cognitive strategies but use less metacognitive strategies (regulatory) than students who were less anxious. According to theory, more anxious students have a pronounced evaluative mindset and a focus on the negative consequences such that the student’s application is hampered and thereby employ the use of lower order cognitive strategies over the more involved regulatory strategies (Elliot \& Church, 1997; Middleton \& Midgley, 1997; Turner et al., 1998).

LIMITATIONS

There were several limitations, in addition to those described above, that pertained to the research conducted in this study. First, the methodology employed was a single-administration questionnaire protocol that assessed students’ trait-based interpretations of the environmental and personal constructs. This correlational-based protocol was limited in that it could not control for students’ prior perceptions of the classroom learning environment and personal parameters addressed nor could it establish the exact direction of the relationship paths presented. Another caution affiliated with data gained from trait-based measures is the accuracy of students’ reporting their perceptions of the environment and personal constructs. There was no way of establishing students’ historical assessments with regards to items such as “My goal is to get a better grade than most of the students” or “Students are asked by the teacher to try new ways of learning science”. Perceptions about the learning environment, achievement goals and motivational beliefs may vary throughout the school year pending the type of emotional successes and failures, and negative or positive affect experienced by students and teachers. Students may only report on events or experiences that are atypical highlights rather than the norm.

One other limitation of the study is concerned with the type of students and classrooms that formed the samples. The schools that had given consent for the involvement of their students in the study may have had a particular interest in being involved or were comfortable that their students would be conscientious subjects in a study involving motivation and the classroom learning environment. The results reported, therefore, may have reflected those of well-adjusted and motivated students rather than accommodate a range of student abilities, interests and attitude to science. Hence, there may have been an inherent form of sampling bias attached with the study which may impact upon the generalisability of the findings.

CONCLUSION

The research conducted found evidence for the proposal that constructs from the fields of achievement goals, self-regulated learning and constructivist learning environments (science education) interact with each other in an interdisciplinary manner to influence the learning of science in high school classrooms. The findings have ramifications for future research accompanying each of these fields. Research in science education attending to students’ acquisition of science-based knowledge and conceptual understanding should cater for the roles of students’ achievement goals, self-regulated learning and motivational beliefs. Constructivist research tends to neglect the motivational, affective and self-regulated aspects of students’ learning and it is encouraging to see that a step towards addressing these intrapsychological dimensions of students’ learning is being attended to in the guise of intentional conceptual change research (e.g., Sinatra \& Pintrich, 2003). However, the work that has examined achievement goals and self-regulated learning in conceptual change contexts has focused mainly on the self-regulated learning dimensions with scant attention applied to the learner’s achievement goals and their motivational beliefs. The present research has demonstrated the adaptiveness of students that adopt mastery-approach goals for their learning while also showing the maladaptive characteristics of the avoidance goals. Students’ motivational beliefs of self-efficacy, intrinsic value and test anxiety were also shown to be crucial antecedents upon students’ achievement goals and self-regulated learning. The contributions these personal-
based constructs have towards promoting learning need to be attended to when examining students’ learning in science.

The second offering for science education concerns the impact of classroom learning environment dimensions upon personal-based factors. Although constructivism has spawned an associated pedagogy, its main focus has been on the intrapsychological dimensions of students. Similarly, intentional conceptual change theories have also been intrapsychologically situated with not much attention paid to the influence of social factors such as the learning environment fostered by the teacher or learning contexts (Hatano & Inagaki, 2003; Pintrich & Sinatra, 2003) or the interaction of these with personal-based factors. The present research has demonstrated the impact that two constructivist pedagogical dimensions, personal relevance and student negotiation, have had on the attainment of adaptive student learning and motivational profiles in high school science classrooms. It is recommended that future work investigates the influence of personal relevance and student negotiation upon achievement goals and self-regulated learning in experimental and correlational formats in both informal and formal curriculum settings in order to confirm the results presented here.

Achievement goal research should consider constructivist pedagogical dimensions as integral environmental influences upon students’ achievement goals. As hypothesised, there was evidence throughout the present research for the positive effects that the constructivist pedagogical dimensions of personal relevance and student negotiation have upon achievement goals and self-regulated learning. Moreover, these effects were beyond the classroom goal structures that have been the focus of contemporary goals research. In addition, it has been observed elsewhere that students express preference for learning environments that foster student social negotiations (Hand, Treagust, & Vance, 1997; Kim, Fisher, & Fraser, 1999; Kinchin, 2004; Tsai, 2000, 2003). Research should attempt to examine the potential that constructivist-based pedagogy has for fostering learning environments that are commensurate with mastery-approaches to learning and explore the impact these may have upon students’ achievement goals.

It is recommended that achievement goals research incorporates the full spectrum of valences (internal and external) for both approach and avoidance achievement goals in the classroom and employ a 2 X 2 goals framework for investigating achievement goals and their relations. The present research found empirical support for the existence of the four achievement goals espoused by Elliot (1999) and Pintrich (2000). Research may also investigate the stability aspects of achievement goals. Finally, research that specifically examines the impact that constructivist-based pedagogical environments have upon the self-regulated learning of students in science classrooms is called for.

REFERENCES


ABSTRACT

This participatory action research was being designed to: 1) Study community context, potentialities, resource and factors which promoted local science learning and teaching. 2) Study local science. 3) Empower researchers and incorporate participants in the process. 4) Synthesize lessons learned for developing network and framework. The participants were from Local Science for the Rajabhat University Network (LSRUN) in the Upper Northeast Region. Data sources were collected from; documentary analyses, research, advancement reports, workshops, focus groups’ discussions, site visits, and in depth interviews. Data were analyzed by descriptive statistics and grounded theory. Both the data and the theory were used independently and jointly to develop a triangulate formula in the concluding analysis. The research findings were as follows: Eight local science research projects focus on community contexts and potentials for developing science learning units. Five of the eight projects studied bio-diversity and resource management. Eight local science learning units were developed. Local flora and fauna Booklets and leaflets for communities were produced. Developing process for researchers and participants was done through four participatory workshops, three consultants’ site visits, mail review and panel review. The finding and suggestions are as follow: 1) researchers avail themselves for the research project 2) the university should be ready to provide emergency budget when necessary 3) Biodiversity in local communities have high potentiality to be study in various subject.

INTRODUCTION

The 1997 Constitution of the Kingdom of Thailand has provided challenging guidelines for education reform in several provisions, and the 1999 National Education Act has placed the holistic reform of education on Thailand national agenda ever since. The educational shell give emphases to knowledge, morality, learning process, and integration of the knowledge about mathematics, science, languages, vocational skills, conservation and utilization of natural resources and the environment. Most of all, knowledge about religion, art, culture, sports, Thai wisdom, and the application of wisdom is also emphasized (section 23). In organizing the learning process, educational institutions and agencies concerned shall enable individuals to learn at all times and in all places. Cooperation with parents, guardians, and all parties concerned in the community shall be sought to develop jointly the learners in accord with their potentiality (section 24).

In Thailand, Indigenous Knowledge is substituted by the term, "Local Wisdom" or "Thai Wisdom", which means the body of knowledge, abilities, and skills of Thai people accumulated through many years of experience, learning, development, and transmission. It has helped solving the problems and contributed to the development of our people's way of life in accordance with the changing time and environment. In the past forty years, however, Thailand's economic and social development has placed an emphasis on industrialization and technology, which depended too much on Western knowledge and know-how. Even worse, such misguided development brought along with it several serious problems such as trade imbalance, urbanization, cultural and environmental destruction, all of which affect the quality of life of the people.

In this research we used "Local Science" as the integration of universal science with Thai indigenous knowledge. We defined "Local Science" as primarily "a learning process and associated holistic body of knowledge which (a) is a result of a rational thinking process with documentation and systematic use of scientific skills such as observation, questioning, experimentation, explanation, analysis, synthesis, and conclusion; (b) covers both environmental and socio-cultural dimensions of the local community, including factors that may effect their future way of life and the impact on their environment; and (c) promotes understanding about the local community among themselves which leads to solutions to specific local problems, enabling self-reliance, sustainable development, and a way of life in harmony with nature." (Ratanapojnud, Phisuthiphorn, Piyapan, Yokubol, 200)

The economic crisis that has occurred during the past years was the outcome of such mistakes and caused us to reconsider, review and re-evaluate our social and economic development plan. We discovered that we had pursued Western way of development and entirely neglected our own indigenous or local knowledge, the splendid treasure that has played important roles in building the nation's unity and dignity. Now it is the time we should turn back to
our own philosophy, our own culture, and our own indigenous knowledge which will be referred to as "Thai Knowledge" here after. (ONEC, B.E. 2541: 41)

Education in the globalization age should therefore be the balanced integration between global knowledge and indigenous knowledge. Therefore, modern science and technology must go hand in hand with indigenous or local knowledge for sustainable development in any community, international understanding, and peace and harmony of the world. On 12-15 December, 2000, at Imperial Queen Park Hotel, Bangkok, it was UNESCO-ACEID Conference “Information Technologies in Educational Innovation for Development: Interfacing Global and Indigenous Knowledge. Some of the main recommendations offers from the conference were: (1) curriculum needs to be flexible in design so that it is more appropriate to local indigenous needs and (2) recognition of, and promotion of, the value of local knowledge by sending students into their communities to find it and bring it back to the classroom. (ACEID, 2000)

In the year 2006, the northeast Network of Rajabhat Universities for developing local science learning and teaching held many workshops on “How to develop Local Science Learning and Teaching”. The workshops focused on promotion teachers, students, and local people to learn together about natural resources, environment and local wisdom. Those workshops and learning processes were factors to change some important thing as (1) teachers, students and local people were developed thinking process and science process, included forming learning network between schools and local (2) they also developed science knowledge such as biodiversity in wet land and mushroom diversity in community forest (3) local science learning units were developed. For the year 2005, the northeast Network of Rajabhat Universities for developing local science learning and teaching focus on how to develop learning, teaching and application of local science on biodiversity of Rajabhat University network in the upper northeast region.

RESEARCH QUESTIONS

1. What were context, potentiality, resources and factors which promote learning, teaching and application of local science on biodiversity of Rajabhat University network in the upper northeastern region?
2. What were scientific data and knowledge which valuable for promotion of learning, teaching and application of local science?
3. How to development process of learning units and learning resources of local science?

OBJECTIVES

1. Study community context, potentialities, resource and factors which promoted local science learning and teaching.
2. Survey biodiversity and its application.
3. Synthesize lessons learned from developing network and framework.

METHOD

This participatory action research is being designed to:
1. Study community context, potentialities, and resources and factors which promoted local science learning and teaching.
2. Study biodiversity and its application in the studied area.
3. Train researchers and incorporate participants in the process.
4. Synthesize lessons learned for developing network and framework of bio-diversity, environment and application management.

PARTICIPANTS

The participants were from four networks from Rajabhat Universities in the upper North Eastern Region. These comprising local representatives: administrators; supervisors; teachers and students from Education Foundations Area and researcher, lecturer and undergrad students

DATA SOURCES

Data sources were collected from various activities through; documentary analyses, research advancement reports, workshops, focus groups’ discussions, site visits, and in depth interviews. All of the above data were analyze by
using; descriptive statistics and grounded theory. Both the data and the theory were used independently and jointly to develop a triangulate formula in the concluding analysis.

FINDINGS

Community contexts, potentialities, resources and factors promoted local science learning and teaching.

There were five Rajabhat Universities formed the Local Science Rajabhat University (LSRU) Network in the upper northeast of Thailand as in figure 1.

![Figure 1: The Local Science Rajabhat University (LSRU) Network, Thailand](image)

**Figure 1** the Local Science Rajabhat University (LSRU) Network, Thailand

![Figure 2: Local Science Rajabhat University (LSRU) Network in the Upper Northeast](image)

**Figure 2** Local Science Rajabhat University (LSRU) Network in the Upper Northeast
Each university set up sub-network in local area, each sub-network comprised of organizations as Science Faculty in Rajabhat University, the Office of Educational Service Area, and Local Representatives. Then the organizations worked together via several workshops to develop local curriculums. Figure 2 represented the structure of LSRU Network and its sub-network.

After the first workshop, each university set up local science research projects, all projects focus on community contexts and potentials for developing science learning units. Five of the eight projects studied bio-diversity and resource management. Figure 3 represented LSRU Network, its 5 universities and 8 projects as Physical environment of Loui River, Curcuma Face Massage, Eco-tour in Phu Pha Lek National Park, Biodiversity in Nong Han Wetland, Mushroom in Dong-yai Forest, Salted Soil in Nong Boe, Soil-cement Block, and Kudnamlad Ecosystem. And table 1 represented its projects, scope of studies biodiversity, local knowledge, organization and participants.

**Figure 3** LSRU Network and its projects

**Table 1** Projects, physical environment, biodiversity, local knowledge and organization and participants
<table>
<thead>
<tr>
<th>Projects</th>
<th>Physical environment</th>
<th>Biodiversity</th>
<th>Local Knowledge</th>
<th>Organization and Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Physical environment of Loui River</td>
<td>Loui River, a tributary of the Mekong River originates at the western shore of the Phu Luang plateau.</td>
<td>There were 44 plant species And animals found were fish (12 species), reptiles (19 species), and amphibian (13 species)</td>
<td>Edible plants and animals Medicinal herbs Farm crops Kitchen garden Hunting Fishery</td>
<td>2 village 1 school Loei Rajabhat University</td>
</tr>
<tr>
<td>2. Curcuma Face Massage</td>
<td>Nakok Sri Songruk was an old community with culture, tradition and indigenous wisdom to used turmeric and also commercial turmeric products.</td>
<td>Turmeric (Curcuma longa Linn.), rhizomatous herbaceous perennial plant, used traditionally by herbalists and indigenous healers as a medicinal herb and cosmetics.</td>
<td>Local people has been used Turmeric as 1. Ingredient of herbal hot compress, herbal hot stream, aroma body scrub and herbal face, herbal soap and body massage. 2. Spice powder (boiled and dried turmeric rhizome) in curries and other cuisine 3. Dyeing powder 4. Medicinal herb for antiseptic for cut, burn and bruise, allegedly helps with stomach problem and other ailments.</td>
<td>Nakok schools Villagers from Nakok village. Lecturers, undergrad student and researchers from Loei Rajabhat University</td>
</tr>
<tr>
<td>3. Eco-tour in Phu Pha Lek National Park</td>
<td>Phu Pha Lek National Park, locates between latitude 17° 15’– 16o 49’ north and longitude 103o 15’ – 103o 50’ east, is a part of Phu Phan Mountain Range lying east and west about 54 kilometers and approximately 200 – 600 meters above sea level. The soil in semi-evergreen forest is sandy soil, and in mixed forest and deciduous forest is laterite. And the stone is mostly sandstone.</td>
<td>There were : 29 families 36 genera of plant trees, most of it were Myrtaceae, Rubiaceae, Papilionaceae, Fabaceae, Dipterocarpaceae. 8 families, 14 genera of ferns as Polypodiaceae, Parkeriaceae 4 families of mushroom as Polyporaceae, Polyporus, Amanitaceae, and Russulaceae (2 forms of lichen (crustose form and foliose form)</td>
<td>Edible plants and animals Medicinal herbs Farm crops Kitchen garden Hunting Weather forecasting</td>
<td>Lecturers, undergrad student and researchers from Sakol Nakhon Rajabhat University</td>
</tr>
</tbody>
</table>
### Table 1 (continue)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Physical environment</th>
<th>Biodiversity</th>
<th>Local Knowledge</th>
<th>Organization and Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. Biodiversity in Nong Han Wetland,</strong> Nong Han wetland is a large pond 22,500 rai, (36 km²) 170, 160 meters (max, min) above sea level and 5-6 meters deep in the rainy season and 1-2 meters deep in the other seasons, with normal water quality and diversity of planktons, plans, fishes benthos and birds. The pond is the second largest in the north-east of Thailand.</td>
<td>The wetlands are composed of diversities of plankton, water plants, fish (both endemics and endangered fish), migrated birds (from China, Europe and Middle East), vertebrate, insects and invertebrate.</td>
<td>Local people could used the wetland by their indigenous knowledge as 1. fishing, 2. collecting edible and medicinal herbs. 3. hunting</td>
<td>1. local representatives 2. administrators and officials from the office of Udon Thani Education Area 2, Kumpawapee 3. 4 teachers with their students from Phontong villages School and Chieng Waer Villages School 4. 7 researchers from Udonthani Rajabhat University.</td>
<td></td>
</tr>
<tr>
<td><strong>5. Mushroom in Dong-ai Forest</strong> Deciduous Dipterocarp Forest community with 1,227,200 m², consisted of plants, animals and physical environment suitable for mushroom growth. Local people used the forest as food resources. They picked vegetables, taro, sweat potato, ants’ eggs, especially mushrooms.</td>
<td>Fifteen species of edible mushrooms were found in the deciduous dipterocarp forest, The dominant species of mushrooms were Russula spp. (Fam. Russulaceae), Amanita spp. (Fam. Amanitaceae), Termitomyces spp. (Fam. Tricholomataceae)</td>
<td>Local people could 1. Used mushroom as food for strength and good health. Moreover, many mushrooms were used as medicine for releasing cold, fevers, painful joint, and digestive system 2. Classifies toxic mushroom 4. Used physical environment to forecast mushroom sprout</td>
<td>Local people from village round Dong-ai forest. Science teachers and students from 2 school. Lecturers, undergrad student and researchers from Loei Rajabhat University</td>
<td></td>
</tr>
<tr>
<td><strong>6. Nongbor salted dam Borabu district Maha Sarakham province</strong> Nongbor salted dam, with rock salted below, people pumped salted water upland to produce salts, that made salted soils spread in vast area, effected cultivation problem and 6 villages were affected from salted soil</td>
<td>-</td>
<td>Local people could used residue material to enrich soil and decrease salinity in soil</td>
<td>People from Hokong, Borabu district. Science teachers and students from Nongdon Hokong school. Lecturers, undergrad student and researchers from Maha Sarakham Rajabhat University</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (continue)

<table>
<thead>
<tr>
<th>Projects</th>
<th>Physical environment</th>
<th>Biodiversity</th>
<th>Local Knowledge</th>
<th>Organization and Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Soil-cement Block</td>
<td>Kalasin Province has many industries with remaining material such as husk, wood ashes, and gypsums.</td>
<td>-</td>
<td>Local people could make soil-cement block by local hand-made process using remaining material.</td>
<td>Science teachers and students from Moesounking Pittayasun school. Sugar crane factory and Tapioca starch production. Lecturers, undergrad student and researchers from Maha Sarakham Rajabhat University</td>
</tr>
<tr>
<td>8. Kudnamlad Ecosystem</td>
<td>Natural wetland, rich in plants and animal diversity. Local people has been used the wetland as food resources. for long time. Succession in Kudnamlad</td>
<td>There were 11 edible herbs <em>(Diplazium esculentum</em> SW., <em>Nephrameris conditilia</em> Presl, <em>Centella asiatica</em> (L.) Urban, <em>Lasia spinosa</em> Thw. 3 species of amphibian, 7 species of terrestrial animals, and 9 species of birds.</td>
<td>Local people could 1. use plants and animal from the wetland as food, medicine and fuel 2. classify toxic plants and animal from edibles 3. produce fishery devices</td>
<td>Science teachers and students from Kudoor Prachasun school. Local people. Lecturers, undergrad student and researchers from Maha Sarakham Rajabhat University</td>
</tr>
</tbody>
</table>

Factors promoted local science learning and teaching.

Factors promoted local science learning and teaching comprised of LSRU network, natural resources, local community, faculties and local knowledge. All factors supported each others and worked together to fulfill learning and teaching in the areas. For example, the LSRU served as a working organization to set many workshops empowered researchers and teachers in research methodology and how to gathering scientific data. Local natural resource played as a studying area for researchers, lecturers, teachers and students to learn how to learn biodiversity in their local and local community served as resources to gather local knowledge.
Figure 4 Factors promoted local science learning and teaching
A Five factor promoted local science B Example of sub unit in local community and local faculty
C Six natural resource areas comprised in LSRU network
Local Knowledge

Local or indigenous knowledge was studied by in-depth interviewing. The interviewees were key informants who lived in local. Transcription of the depths were done and used as data to be concluded. We found that the knowledge has been transferred from ancestors to newer generations by elderly people, Tau Jum (spiritual ceremony conductor) local officials and occupational leaders. Transferred knowledge was done by observation, verbal communication, training, questioning, and problem solving and monitoring the environment. Figure 5 presented who were local Wiseman (local wisdom), which ways local knowledge could be transferred, what sociological factors it embedded and what classification of the knowledge has been done by local people.

![Local Knowledge Diagram](image-url)

**Figure 5** Local or indigenous knowledge ways

Local knowledge was embedded in sociological factors, classified by the way of utilities, transfer by local people via many ways.

Local Science Knowledge

Local science knowledge, studied by scientific method and process, were as follow: 1) succession of Kudnumlad ecosystem; biodiversities of Kudnumlad (11 edible herbs and 39 animals); 2) Phu Pha Lek National Park (29 families and 36 genus of plants); 3) Loi River (44 plants and 44 animals); 4) physical environment of Loi River; 5) life cycle and ecosystem of Mushrooms (15 species) and nutrients of mushrooms (10 species) in Dong-yai community forest; 6) ecosystems in Nong Han, epidermis (9 species), vascular tissues (3 species) and sporangium of water plants (2 species), microorganisms in food from Nong Han and water animal parasites (8 species); 7) process of cement block; 8) amount of curcumin in curcumias and fertilizer of salted soil. Figure 6 Biodiversity studied in five areas. For those researches, biodiversity was scoped in ecological and species diversity.
Local science learning units.

Local science learning units developed by several workshops both in the LSRU network and its sub-network and there were 8 local science learning units developed as follow; 1) Kudnamlad’ ecosystem, 2) Eco-tour in Phu Pha Lek National Park, 3) Physical Environment of Loi River, 4) Nutrients, Life Cycle and Ecosystem of Mushrooms in Dong-yai Forest, 5) Nong Han Heaven Land, Biodiversity of Ecosystem in Nong Han, Biodiversity of Water Animal Parasites, Microorganism in Food from Nong Han, 6) Production of Soil - cement Block from Industrial Remaining Material, 7) Curcuma Face Massage Process, 8) Salted Soil in Nong Boe Water Reservoir. A number of booklets and leaflets for communities were produced by researchers on the local flora and fauna. Among these are; Kud-oaa History, Tourist Guide for Phu Pha Lek National Park and Food Safety in Nong Han.

Developing process for researchers and participants was done through four participatory workshops: 1) proposal developing determined by term of reference consistent with local need, institute strength and focus area; 2) participatory action research; 3) how to develop integrated science learning unit; 4) science communication and research advancement report. Beside these workshops, there were three consultants’ site visits, mail review and panel review. These activities were designed to create a rapport in order to facilitate working within the country. Framework of the developing process for researchers and participants was summarized as in figure 7. Along with the process, each subunit of LSRU network worked within its organizations. Framework of each subunit comprised of many activities as shown in Figure 8.
**Figure 7** Developing process for researchers and participants
The process comprised of four workshops and advisory activity.

**Figure 8** Process of local science learning unit via participatory action research as a model for professional development.
1) indigenous knowledge should be incorporated into learning units for primary, secondary and undergraduate level
2) biodiversity in local communities has high potentiality to be study in various subjects such as medicinal plants, cosmetics herbs, saunas herbs, history, culture and so on.

REFERENCES
ABSTRACT

Research studies have shown that the proper integration of Information and Communication Technology (ICT) in teaching and learning offers considerable pedagogical benefits, especially to low-achievers. This paper reports a study carried out to investigate the use of word-processing software as a pedagogical support in the teaching and learning of Basic English in a pre-vocational classroom of twenty students in an all-girls urban secondary school. The primary focus of the study was on the effects of the software on the students’ performance in English and their motivation to learn the subject. The findings tend to suggest that the use of the software improved the performance of these students in English and increased their motivation to learn the subject. It also helped increase students’ self-confidence in the subject. The new learning environment favoured peer tutoring and provided the teacher with the opportunity to give more individual attention to the students.

BACKGROUND, RATIONALE AND CONTEXT

Research studies tend to show that ICT has the potential to enhance the teaching and learning process (Bork, 2003; Dwyer, Ringstaff, & Sandholtz, 1990; Lee & Dziuban, 2002; Whitworth & Berson, 2003). ICT also tends to enhance learners’ motivation towards learning and increases the self-confidence of low achieving students (Romi & Zoabi, 2003). Giving these students the opportunity to improve their writing and presentation skills through ICT can lead to a greater involvement and commitment to their learning. Through the use of word-processing, students who otherwise do poorly at writing and have little interest in this aspect of their work improve their self-esteem, their commitment and perseverance in the learning tasks (Cox, 1999). It has been shown that ICT, in the form of a word processor, can positively influence learners’ performance in English as well as their attitudes towards the subject (Mumtaz & Hammond, 2002; Oldfather, undated; Schneider, 2004).

The participating school in this study is a secondary girl’s school in Mauritius with students aged between 12 to 13 years. The school has a pre-vocational stream along with the normal mainstream. Students in the pre-vocational stream are low achievers (Ministry of Education, 2006) who have not been able to have access to mainstream education. The school administration has given its full support to the pre-vocational scheme and considers the development of the pre-vocational students as a challenge. The aim of the school is the re-establishment of the motivation of the students for learning. The purpose of this study was to investigate the effects of a word processor on the motivation of pre-vocational students in learning English and their performance in the subject.

Many countries have been researching on how ICT can contribute to improving performance of low achievers. Romi and Zoabi (2003), for instance, examined the attitude of Arab dropout youth (15-18 years of age) toward the use of computer technology and the influence of this on their self-esteem. Bradshaw (1995) in Canada examined high-school dropouts aged 13-19. He reported that the use of multimedia equipment enhanced motivation and self-image, and internalized knowledge and skills. In Mauritius, however, no apparent research has investigated the use of word processor as a pedagogical support with low achievers.

In Mauritius, Creole is the mother tongue but English is the official language and a compulsory component of study at primary and secondary school levels. The Mauritian government has a policy of offering learning opportunities to all students including low-achievers for the mastery of the essential competencies to ensure literacy. ICT can become a valuable support to implementing this policy. According to the School IT Project, schools will be expected to integrate ICT across the curriculum as from 2006 (Ministry of Education, 2002). As such, ICT is expected to be part of the pedagogical support repertoire of the teacher for the teaching and learning of the secondary school subject areas. Findings from this research can be used to inform policy makers, teachers and teacher education
institution on the potency of ICT in the prevocational sector. It will be a step towards bridging the gap between policy, research, theory and practice.

The Mauritian prevocational education system

The duration of primary schooling in Mauritius is six years. A child is admitted to primary school at the age of six. A national examination, known as the Certificate of Primary Education (CPE), is conducted at the end of the sixth year of primary schooling. The CPE results are then used to decide whether or not the child is promoted to secondary school. Secondary schooling consists of two streams: the main stream which is meant for pupils who have passed the CPE and the prevocational stream for students who have failed the CPE either twice or once or who are too old to stay in primary education (Ministry of Education, 2001). Prevocational students do not get access to mainstream secondary education. Repetitive failures and constant labelling are generally perceived to be some causes for their lack of confidence and low performance in schools. Prevocational education therefore recommends the use of appropriate pedagogical strategies to increase the self-confidence and performance of the students. The prevocational students are generally perceived to lack self-confidence in learning English. In the Mauritian context 'Basic English' refers to word recognition, and building simple sentences.

THE USE OF ICT WITH LOW ACHIEVING STUDENTS

Low achievement is the result of lack of motivation. Barry and King (2000) refer to this as a lack of achievement motivation. Students having difficulty writing properly have a negative attitude towards writing. Writing with pen and paper is not an activity that encourages self-confidence (Street, 2000). Students are reluctant to write because they have experienced failure and they have doubts about their abilities. Street goes on to say that self-confidence determines how much effort the students expend and how long they will persist in the activities. Through the use of computers, and word processor in particular, their attitude towards writing can improve and so can their performance and self-confidence (Griffin, 1991) and their motivation (Chen & Looi, 1999; Romi & Zoabi, 2003).

Waldman (1997) sees great possibilities in using computers for working with students with learning difficulties as it provides a learning environment where pupils are active and enjoy the tasks. These students see the computer as an interesting and enjoyable aid to learning. It can aid in increasing learners’ on-task concentration (Romi & Zoabi, 2003) and academic performance (Fluck & Robertson, 2002). Easingwood (2000) argues that the use of word processor can alter the act of writing. Work can be typed and re-drafted without traces of the many changes. This changes the attitude of the reluctant writer. Gay (1991, cited in Street, 2000) says that attitude of learners having writing difficulties improve when they work with the word processor. The word processor reduces the demand on memory and enhances creativity and as such it can be considered to be an "aide-mémoire"(Davis et al., 1999).

With a word processor the text is malleable (Schneider, 2004). It is easy to analyze words, to manipulate them, to focus on parts, draw students’ attention to letters, words and orthographic patterns within words and provide effective scaffolding. Scaffolding is a support that enables the learner to perform a task which would have been difficult without the scaffold (Scribshaw, 1999). Word processor features such as spelling checkers and colour change when mistakes are made are useful aids that improve the quality of student writing.

THE ROLE OF THE TEACHER

In the Mauritian context, prevocational teachers are expected to provide the necessary conditions and environment that will support students in their learning. The use of word processor in the classroom can be one way for teachers to reshape the traditional classroom into a comfortable yet rigorous, learning environment, one conducive to learning for students having difficulties in writing (Street, 2000). The classroom dynamics in a computer classroom can become much more fluid and democratic, with teachers able to move around the room adopting a child-centred approach. The ability of the teacher to interact with students while they compose and revise may be among the most important changes that ICT brings to the teaching and learning of basic writing skills. The teacher's response is immediate, personalized, and specific.

The role of teacher is critical in guiding the writing process, providing feedback, and encouraging revision (Holum, 2001). Teachers need more time to reflect on the learning objectives when word processor is used. The focus needs to shift away from the technology to the development of writing skills. When using word-processing software, students sometimes get carried away by the features of the software and forget that their real task is to write (Grant, 2001). It becomes important for the teacher to ensure that students use their time for activities relate to the learning objectives rather than the features of the software.
RESEARCH QUESTIONS

The study investigated the use of word-processing software in the teaching and learning of English in a pre-vocational class in an urban district of Mauritius. The primary focus of the research was to study the effect of the word processor on the performance of twenty pre-vocational students in English and on their motivation to learn the subject. The following research questions guided the study:

- How does the use of word-processing software influence the performance of pre-vocational students learning English?
- How does the use of word-processing software influence the motivation of the pre-vocational students to learn English?

METHODOLOGY

The participants in this study consisted of twenty female students (aged 12-13) in a pre-vocational class. Classes were conducted in the computer laboratory which provided a 1:1 pupil:computer access ratio. The pre-vocational teacher also participated in the study. A qualitative case study was the main method used. This research method was chosen because the aim was to gain insights, to discover, and to interpret (Merriam, 1988; Walsh, Tobin, & Graue, 1993). Unobtrusive observations, follow-up interviews, group interviews, physical artefacts and demographic questionnaire were used as instruments to collect data, in an attempt to describe as fully and as richly as possible, what was going on in the classroom when word-processing software was being used as a pedagogical tool. It was possible to probe the teaching and learning process, the intellectual and emotional experiences of the students, their motivation, and their interactions with the teacher and with peers.

At the beginning of the research, a demographic questionnaire was administered. The purpose of this questionnaire was to obtain data about the background of the students, their degree of motivation and self-confidence in studying English. Subsequently, twelve English lessons of forty minutes were conducted using the software as a pedagogical tool. Each lesson was observed and recorded resulting in a total of eight hours of observation. Follow-up interviews of students and the teacher were conducted after observations. Group interviews with students as well as informal conversations with the teacher were also conducted toward the end of the study.

An attempt at making the researcher invisible

Prior to the study, informal visits and informal observations were conducted to capture a holistic view of the situation in the study setting and also to acquaint the students and the teacher with the researcher's presence. During two weeks, about five times per week, the researcher conducted informal visits in the pre-vocational classroom for 15-25 minutes each. Before coming into the classroom, the researcher talked with the teacher about the place where the former would sit in the room, how she would be introduced to the students and how she would respond when a student approaches her (Good & Brophy, 2000). Consequently, most of the time the researcher was seated at the back of the classroom.

During the first few visits, students were asking questions of the pre-vocational teacher about the researcher's presence and were from time to time looking at the researcher. After one week the students were used to seeing the researcher and the students also started to have informal conversation with her. The attitude of the pre-vocational teacher also changed after five or six visits. She was more at ease and the researcher's presence did not seem to disturb her. Sometimes the researcher had informal conversation with students in the school yard. Students talked about the school and their family.

Data analysis

Throughout the study the researcher recorded classroom observation data in a diary. Each classroom observation was referred to as a visit. Twelve visits were conducted. After each visit the researcher read the notes, looked for pattern, similarities and differences and tried to revise or confirm preliminary explanations (Gay, 1997). Follow-up interviews were conducted with the teacher and students to clarify actions. Collected data was recorded in a table by clustering categories and recording the frequency of occurrences to be able to find patterns (Hoepfl, 1997). After each visit the table was updated and new categories were identified. Throughout regular classroom observations and interviews various patterns and categories emerged.
DISCUSSION AND FINDINGS

The expectation that a clear result would emerge from a study of such short duration was considered optimistic. However, the findings provided greater insight as to the effectiveness of word processor as a tool to teach English to the prevocational students. The following findings emerged:

Motivational gain

The use of word processor motivated the students to learn English. The pre-vocational students initially expressed their reluctance to write because they experienced many failures and had doubts about their abilities (Street, 2000). The findings indicate that by the end of the study, the use of the word processor had motivated them to learn English.

The following behaviours of students were common:
- Rushing to the computers.
- Showing fascination for the pictures on the screen.
- Showing eagerness to start to work.
- Staring at the screens with eyes open wide.
- Looking forward to receiving a printout of their work
- Wanting to stay after the bell has rung or an unwillingness to leave the computer room.

During group interview students were asked how they felt when a word processor was introduced into the classroom they said:
- Fara: I am proud to use computers to learn English. I have shown my printout to my parents and relatives.
- Teena: If teacher uses computers in all subjects, I am sure I will learn better.
- Jane: I like to work with word processor because we do not have to write with pen.
- Paula: The pictures are interesting.
- Rama: If we know how to work on computer we will have a job.

Increase in individual attention

During lessons a teacher walked around the classroom and checked the work of students individually. While walking around, she could cater for individual needs of students. It was observed that when moving about, teacher could immediately correct the students' work and explain some concepts thus giving immediate feedback. This finding is supported by Gay (1991, cited in Street, 2000) which stated that when students used word processor, they worked at their own pace and this allowed teacher to assist them at an individual level.

To keep everyone on-task, the teacher gave extra work to those who finished first. For example, one student, Teena, finished before the others on a task which was to identify some pictures and to type the appropriate name next to each one. After a short while, Teena completed the task. The teacher then gave her the extra task of constructing simple sentences based on the pictures. In a pupil-centred environment like the one in the study where the students worked on their own and where they take responsibility for working towards set tasks, the teacher is better able to give more individual attention to the students (Smeets & Mooij, 2001).

Performance gain

The performance of the students in English increased as measured by the speed with which they completed set tasks and the number of mistakes they made. Data from the demographic questionnaire revealed that students were reluctant to write on paper using a pen and they commented that writing in copybook seemed to be unpleasant. However, by the end of the study, there was evidence of an increase in the performance in English such as word recognition skills, a set of skills they were struggling with prior to the study. Most students were able to type words without errors or to build simple sentences after some time. For example, Jane who could not write simple words and could not recognise some characters experienced improvement. She showed a keen interest in computerised class from the outset. After three weeks of observation, she started to type words with more confidence. During follow-up interview, Jane commented that:

In primary school I could not write properly but now I am able to write many words without mistake. Computers helped me a lot.
This pattern of improvement in writing was also found with other students. Below are the verbatim reports of a few students:

Farah: *I make less errors because when the word is underlined in red, I can erase and rewrite easily.*
Tina: *I learn better when the teacher uses word processor.*
Lyne: *My work is neat and presentable.*
Sarah: *My copybook in primary school contained lot of blot out words which made it dirty. My work is more presentable on the computer.*
Rebecca: *I can remember words because of the pictures.*

Another student Mira, instead of typing the word "pencil" wrongfully typed "pemcil". She stopped and seemed confused because the word was underlined in red. A long gaze at the word followed. She looked at the paper she had on her desk and then corrected her error. A smile was seen on her face. In follow-up interview with Mira she said "when I looked at my paper I noticed that I had typed "m" instead of "n". In this case the word processor has given an immediate feedback and a cue by underlining the word. Mira has self-corrected her error and was responsible for the learning process.

Various factors may have contributed to rise in performance such as factors inherent in word processor and the classroom climate. Inherent factors of word processor such as facilities for drafting and re-drafting, spell check, colour change, printout facilities and ease of using pictures with text instilled a sense of accomplishment and self-confidence in the students. This may have helped the students in their learning (Easingwood, 2000; Street, 2000). The classroom environment which is non-threatening, pleasant and enjoyable (Fisher, 1986; Newby, 1998; Waldman, 1997) coupled with more attention from the teacher (Street, 2000) may also have influenced the performance of the students.

### Teacher as the key agent

The findings of the study suggest that word processor has the potential to improve writing skills of low achievers but the teacher remains a key factor. The type of instructional strategies she used may have contributed to making the use of word processor effective. Through regular access to the technology and its use in learning English, students who were initially reluctant to learn with the computer were able to do so with time (Chen & Looi, 1999).

In this study the research found that the teacher played a major role. She decided about the software and planned the different activities. Teacher said, "when planning lessons, I have to reflect a lot to design new activities" and she also said "when I used word processor I can easily prepare interesting teaching materials". Further conversation with her revealed that she was enthusiastic about the English class and she found that students were highly motivated. She also found that they were less off-task. She said that word processor allowed her to use an innovative approach to implement the curriculum.

### Peer-to-Peer Interactions

The use of the word-processing software also led to an increase in the degree of peer interaction. Below are comments from students:

Fara: *When word processor is used we can talk and help our friends, teacher allowed us to share our views provided that we did not disturb the class. In other classes when we help our friends teacher thinks we are not following the class.*
Lucie: *When I encounter some difficulty I ask my friend to help me. I understand when we work together.*
Teena: *When I work with my friend I am able to exchange ideas and she explains the difficult word*
Lyne: *When my friend helps me I am able to arrange the sentence in correct order*

ICT as a teaching and learning tool seems to afford more peer-tutoring in the class. In this study, students were constantly helping their classmates and this was encouraged by the teacher. Follow-up interview with students revealed that they enjoyed working with peer and they are able to complete more difficult task.

Overall, the findings show the enthusiasm with which the students and the teacher used the word processor in the classroom. It was also found that simply exposing the students to the word processor motivated them. They were excited to use the technology. The use of ICT for learning English instilled a degree of intrinsic motivation inside the students. They were enthusiastic about having a printout of their work, but the teacher only seldom used the printout facilities as not all personal computers were connected to a printer. Most of the students also expressed a desire to work on computers.
LIMITATIONS OF THE STUDY AND A FUTURE RESEARCH AGENDA

No research can claim to be without limitations. One limitation in this study stems from the fact that the teacher rarely provided tasks that suit the individual needs of the students. Everyone one was given the same task at the start but they were given extra tasks later upon completion of previous ones. Further research could reveal the impact of tasks designed to meet the individual needs of each student and assess the gains and pattern of interactions among students and with the teacher. The duration of the study also present a limitation. The study was conducted over a short period of time. A longitudinal research may shed more light on the validity of the findings and the sustainability of the performance and motivational gains once the novelty of the technology has worn off.

Due to the limited nature of this study and the apparent absence of similar studies in Mauritius, multiple directions for research are possible. A few areas for further research could be as follows:

- According to Guldberg (2002), literacy has a transformative effect on students' thinking. A study could be conducted to see whether the use of computers develop reflective skills in students. A future research area could be to investigate the use of ICT in the development of higher order thinking skills.
- Replication of the study and its extension over a longer period of time could be considered in other pre-vocational settings in Mauritius.
- The study has identified a number of categories. Each category can become the focus of separate studies, for example, whether the level of motivation for and performance in the English language are maintained or increased or decline as the novelty wears off.
- Research findings concluded that when word processor was used with the students, they were able to acquire a number of English language competencies such as word recognition, typing of words, and matching words with objects. Other researches could investigate whether the use of a word processor can further develop other competencies such as reading skills and communications skills.

CONCLUSION

One of the objectives of the pre-vocational curriculum is to open access to onward learning. ICT can be a valuable tool that contributes towards the attainment of this objective. The study reinforces the place of technology in the classroom and makes a case for its use with low achievers. Through the use of a word processor, students have demonstrated performance gains in English as well as gains in the motivation to learn. Their self-confidence was also boosted as they made fewer mistakes and as they produced satisfying work. Also, teacher was able to provide more individual attention to the students. Furthermore, students were able to self-correct their work, improve their writing, were able to construct simple sentences based on the feedback from the teacher and with the support of the software and peers. Intrinsic motivation for computers changed their attitude towards the English Language. Re-establishing the self-confidence of the pre-vocational students and increasing interest and motivation in learning is possible through the proper use of word processor in the classroom.

Moreover, a positive classroom climate conveyed by the classroom space and a one-to-one pupil:computer ratio also added to the effectiveness of the approach. Word-processor tended to contribute to a more appropriate classroom ambiance by favouring peer-tutoring and by providing the teacher more time to give individual attention to the students. Students could get immediate feedback from teacher. The classroom climate allowed peer-tutoring, an instructional strategy encouraged by the teacher. Students consulted their peers and were able to proceed to more difficult tasks. Policy makers and educational authorities may have to seriously consider ICT as a pedagogical support in the classroom.
REFERENCES


IMPROVING THE LEARNING ENVIRONMENT IN HEALTH SCIENCE CLASS: A CASE STUDY IN THAILAND

Achara Jinvong
Udonthani Rajabhat University
Thailand

Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

The main purpose of this classroom action research was to improve the learning environment of a tertiary Health Science class in Thailand by using the Constructivist Learning Environment Survey (CLES) and a constructivist learning approach. The study combined quantitative and qualitative methods and was conducted over one semester in four stages: 1) assessing the students’ perceptions of their constructivist learning environment; 2) constructing an intervention based on constructivism theory in order to attempt to improve the learning environment; 3) implementing the intervention; and 4) evaluating the success of the intervention by re-assessing the learning environment using the CLES. Qualitative data were obtained from informal observation, focus group discussions, and student journals. The results indicated that the adapted Thai version of the CLES is appropriate for use in Health Science classes in Thailand as it was shown to be valid and reliable in both Actual and Preferred Forms. The results also revealed that the CLES and a constructivist learning approach can be used as effective tools in order to improve the learning environment of a Health Science class. An improved learning environment could result in improved student learning outcomes. The qualitative results supported the results from the questionnaires.

BACKGROUND

In the last decade, Thai teachers and educators have had many concerns about educational achievement and the quality of the Thai education system. For example; we talk about how teachers teach, how students learn, the factors which have an effect on students’ learning outcomes, improving the learning environment and improving teaching and learning strategies in order to improve students’ learning achievement. Thai educators consider that there are many causes related to these problems. The first cause is related to the learning environment because students spend approximately 20,000 hours in the classroom by the time that they graduate from college (Fraser, 2001). Research in the past has shown that the classroom environment is an important factor that has a strong influence on students’ learning achievement (Fraser, 1998). Previous research studies conducted in Thailand have reported that the traditional classroom environment in Thailand is not enabling the learner to engage in active learning in the classroom (Jeeravipoonwan, 2004; Puacharearn & Fisher, 2004; Suwannasit, 1997; Wanpen & Fisher, 2004). Also, the Thai culture is another factor that has a huge influence on the learning environment because Thai students are accustomed to passive learning behaviour. They are taught to be humble by strictly obeying what their elders say and not to ask questions neither in nor outside the classroom. Raising a voice in the classroom is a sign of disrespect to the authority of the teacher (Chuwattanakul, 2002). Research in the past shows that without questioning in the classroom the interaction between teachers and students will not be enough to create a two–way communication. Without two–way communication between students and teachers, a useful teaching–learning environment will not exist (Oliva, 1989). According to the 1999 National Education Act, significant efforts are being made to reform Thailand’s education system. This act has provided a new paradigm of learning which addresses the importance of learning environments and constructivist perspectives. The Office of Educational Reform decided to make a major change and introduce and promote new teaching and learning strategies that emphasized student-centred methods and addressed on the importance of suitable learning environments and effective learning strategies (Ministry of Education, 2000).

Udonthani Rajabhat University has more than 5,000 students and provides several courses in five faculties. The Health Science Program is situated within the Faculty of Science. The first author works as a lecturer and mentor of undergraduate students who are enrolled in this Health Science course and has found that there are problems related to the learning environment and learning achievement of these students. A traditional teaching method has been used and although it was not entirely bad, there are many problems related to it, and these problems have an influence on students’ learning achievement. We were interested in conducting an action research study in order to try to improve a learning environment in a health science class by using the Constructivist Learning Environment Survey (CLES) as a tool for developing a constructivist learning environment in the classroom and creating a new teaching approach based on constructivism theory. Another
motivation for conducting this research was that it is apparent in the literature on learning environments research that almost all work been done in other countries and in the pure science classrooms. For examples, physics, chemistry or mathematics classrooms. Very few research projects have been done in Thailand or in applied science classrooms and none of them refer to a Health Science class.

PURPOSE OF THE STUDY

The main purpose of this study was to improve the health science classroom learning environments in Thailand through the use of the Constructivist Learning Environment Survey (CLES) and a constructivist learning approach.

OBJECTIVES

The purpose of this research led to the following objectives that guided the research. The research objectives were:

- to validate an adapted version of the CLES for use in Health Science students at university level in Thailand;
- to describe students’ perception of Health Science classroom environments from a constructivist perspective;
- to investigate differences between students’ actual and preferred perceptions of constructivist classroom environments in Health Science classroom; and
- to investigate differences between students’ perceptions of classroom environment in Health Science classrooms before and after the implementation of a constructivist learning approach.

THEORETICAL FRAMEWORK

Learning environment

The learning environment is a very important factor affecting students’ achievement because students spend a huge amount of time at the school, college or university. Over the years, researchers have developed many instruments to assess students’ perceptions of their classroom learning environments (Fraser, 1998). These instruments have been translated into various languages, and have been used in different fields, different countries and at different levels. The information from assessment of classroom learning environment is a useful source for teachers, providing student feedback, to guide them, on ways to improve their teaching and learning. Research studies in the past also show that the classroom learning environment is an important variable and has a strong influence on students’ learning outcomes (Fraser, 1998, pp. 1-5).

Constructivism

Von Glasersfeld (1989) described constructivism as a theory of knowledge with roots in philosophy, psychology and cybernetics. From a constructivist perspective, knowledge is constructed as a result of cognitive processes within the human mind and through interaction with his environment. Bruner (1996) described constructivist learning as an active process in which learners construct new ideas or concepts based upon their current and past knowledge. Constructivism recognizes the construction of new understanding as a combination of prior learning, new information, and readiness to learn. Individuals make choices about what new ideas to accept and how to fit them into their established views of the world (Brooks & Brooks, 1993).

There are two basic principles of constructivism: the first is that knowledge is not passively received from the environment, but students actively construct their own knowledge; and the second describes knowledge construction as an adaptive process in which the learners link their prior experiences to construct new knowledge that relates to the world outside. (Treagust, Fraser, & Duit, 1996). In this research study, constructivism was used as a basis for determining intervention strategies in order to improve classroom learning environment and attempt to improve students’ learning outcomes.

Characteristics of the constructivist teaching approach

The constructivist classroom presents the learners with opportunities to build on their prior knowledge to construct a new knowledge and understanding from authentic experiences that is related to the topic. From a constructivist perspective, Brooks & Brooks (1993) list some of the important characteristics that guide the work of a teacher and learner. In constructivist classroom, teachers do not teach in the traditional sense of delivering instruction to a group of students. Rather, they use material with which the learners become actively involved through manipulation or social interaction. Learning activities include observing, collecting data, generating and
testing hypotheses, drawing conclusions and working collaboratively with others. The teacher and students are always reflecting on their learning experiences. In this approach, students are taught to be self-regulated and take an active role in their learning process by setting their learning goal, monitoring and evaluating learning progress, and going beyond basic requirements by exploring interests. Thus, in the constructivist classroom, the learners actively construct knowledge in their mind in an attempt to make sense of their world, and learning will likely emphasize the development of meaning and understanding. Driver (1989) stated that one of the most important points for this approach is that well-planned learning activities must be adopted in order to help students to know how to learn and encourage them to achieve their learning goal. Therefore, the implication of constructivist teaching for instructional design must relate to these themes.

The Constructivist Learning Environment Survey (CLES)

The CLES was developed to enable researchers and teachers to monitor the constructivist teaching approach and to address key restraints to the development of a constructivist classroom climate. The original version of the CLES (Taylor, Fisher, & Fraser, 1997) was based on a theory of constructivism which refers to an epistemology that views knowledge as being ‘constructed’ (or generated) within learners’ minds as they draw on their existing knowledge to make sense of perplexing new experiences. The CLES was redesigned (Hardy & Taylor, 1997) to incorporate constructivist and critical theory perspectives on a cultural framing of the classroom learning environment. The CLES is available in two forms, the Actual Form and the Preferred Form (Taylor, Dawson, & Fraser, 1995). The item wording of the Preferred Form is slightly changed from the Actual Form, for instance, the Preferred Form uses phrases like I wish. Each form of the CLES contains 30 items altogether and is composed of five scales each of six items with each scale designed to measure a student’s individual perception of her or his constructivist science classroom learning environment. The five scales are Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The alternatives response for each item are Almost Always, Often, Sometimes, Seldom, and Almost Never.

RESEARCH DESIGN

The research design used in this study is action research employing a multi-method approach utilizing both quantitative and qualitative methods.

Sample size and sample selection

The sample to validate the Thai version of the CLES consisted of 100 undergraduate students who study in the Faculty of Science at Udonthani Rajabhat University which randomly selected from the third-year cohort. The sample of student who participated in the action research process consisted of 18 students in one Health Science class at the undergraduate level in the Udonthani Rajabhat University, Thailand. A purposive sampling technique was used which included two criteria that the students must be enrolled in Health Science Subject; and must be willing to participate in this research study.

Instrumentation

The Constructivist Learning Environment Survey (CLES) was used to assessing students’ perception of a constructivist learning environment in a Health Science Classroom. The instruments used to assessing students’ attitudes on AIDS topic is the Attitude toward AIDS Questionnaire (ATAQ) and the Student Knowledge of AIDS Test (SKAT) were used to assessing students’ knowledge about AIDS. Qualitative data were collected from open-ended questions for assessing students’ pre-instruction concepts about AIDS before the intervention and the focus group discussion and student journals also used for collected qualitative data after complete the intervention.

Data Collection

The CLES was used on three occasions, firstly, in the initial stage of pilot testing in order to ensure that it was reliable and valid for use in undergraduate Health Science classes in universities in Thailand. The CLES also was used to investigate students’ perceptions of constructivist classroom environments in two later data gathering stages, before and after the intervention. The ATAQ and the SKAT were used for assessing the results of the intervention in order to measure students’ learning achievement after the intervention was completed.

Qualitative data were obtained from four main strategies, open-ended questions were used to investigate student’s pre-instruction concepts about AIDS. Focus group discussions were used for reflection and discussion about the results of the CLES in order to construct an appropriate intervention, and to discover students’
opinions about the intervention process and the results of the intervention. Students were asked to write their learning experiences in journals during the period of the intervention in order to monitor and reflection on their learning about AIDS. Informal observation was used throughout the research cycle and an observation checklist was used during the implementation of the intervention.

Data Analysis

Quantitative data analysis

The class mean scores of student’s perceptions of their constructivist classroom environment, students’ attitude toward AIDS, and students’ knowledge about AIDS were used as the units of analysis. The Analysis of the CLES data included factor analysis, reliability, and discriminant validity. Descriptive statistics including the frequencies, percentiles, mean and standard deviation were used to describe the results of the sample’s demographic data. A paired t-test was used to compare students’ perceptions of their actual and preferred classroom environments and using independence t-test to compare students’ perceptions of their actual classroom environments before and after the intervention.

Qualitative data analysis

The qualitative data from open ended question, focus group discussions, students’ journal and observations were analyzed by content analysis and organization of the information into categories, grouping and ordering of the answers, searching for the patterns and then drawing conclusions.

The stage of action research

This study consist of four main stages as described following.

Stage 1: Pre-assessment of the students’ perceptions of their learning environment and students’ pre-instruction concepts about AIDS.

The adjusted Thai versions of the Actual Form and Preferred Form of the CLES were used to assess the students’ perception of their learning environment in one Health Science classroom. Open-ended questions used to assess the student’s pre-instruction concepts about AIDS.

Stage 2: Construction of the intervention based on constructivism theory in order to improve the learning environment.

The teacher provided an opportunity for the students to become involved in this stage. A focus group discussion was used to generate feedback for reflection and discussion about the results of the CLES. Then, the teacher and the students worked together in order to construct an appropriate intervention based on constructivist theory attempt to improve learning environment. The students were encouraged to set their learning objective and planned about the learning activities based on a constructivist approach.

Stage 3: Implementing the intervention.

This stage was conducted over the duration of three months. The constructivist learning activities used in this health science class included various authentic tasks. For example, self-directed learning, small group discussion, a game, field trip, and presentation. Authentic assessment aligned to this process in each learning activity of the intervention. After finishing each learning activities, the students generated conclusions about the issues that they had learned.

Stage 4: Evaluation of the intervention

At the conclusion of the intervention, The Actual Form of CLES was used for re-assessment of the students’ perceptions of their constructivist learning environment. The focus group discussion and students’ journal were also used to collect qualitative data in order to further explain the quantitative data. The ATAQ and the SKAT were used to assess students’ attitudes and cognitive achievement about AIDS.

RESULTS AND DISCUSSION

The results of this study are presented in three parts. The first part describes the validation of the adjusted Thai versions of the CLES. The second part provides the results of improving the constructivist learning environment. The last part presents the student’s satisfaction of the constructivist learning approach attempt to improve their learning environments.
Validation of the CLES in Thailand

Before beginning the action research study, the Actual and Preferred Forms of the original version of the CLES were translated into Thai language and back-translated into English by a translator who had expertise in both languages. A principal components factor analysis with varimax rotation confirmed the five scale nature of the CLES indicating that it assesses five unique aspects of the constructivist classroom environment. The alpha reliability values and discriminant validity also were satisfactory (Jinvong, 2007).

The improvement of constructivist learning environment.

The results of this study indicated that the intervention based on the constructivist teaching approach led to an improvement in students’ perception of the constructivist learning environment in the Health Science class.

The results of pre-assessment using the CLES show that the average item mean scores on the Preferred Form are significantly higher than on the Actual Form on all CLES scales. The average item mean scores of the Actual Form ranged from 3.00 to 3.62 and the Preferred Form ranged from 3.82 to 4.47.

After completion of the intervention, the results from the post-assessment indicated that the item mean scores of each scale of the Actual CLES had increased from the pre-assessment. There were significant differences between pre and post-actual on all scales of the CLES.

When comparing the average item means of each CLES scale between the post-actual (after intervention) and the preferred learning environment (before intervention), it is clear that the discrepancies between post-actual and preferred perceptions mean scores decreased on all scales (see Tables 1 and 2).

Table 1
*Average Item Mean Scores and Standard Deviations for Each Scale of Student’s Pre-Actual and Post-Actual Perceptions of the Constructivist Learning Environment Survey*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean Pre-Actual</th>
<th>Mean Post-Actual</th>
<th>Standard Deviation Pre-Actual</th>
<th>Standard Deviation Post-Actual</th>
<th>Mean Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>3.62</td>
<td>3.94</td>
<td>0.51</td>
<td>0.52</td>
<td>0.32</td>
<td>1.91*</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>3.56</td>
<td>3.93</td>
<td>0.62</td>
<td>0.39</td>
<td>0.37</td>
<td>2.81**</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>3.59</td>
<td>4.37</td>
<td>0.68</td>
<td>0.46</td>
<td>0.78</td>
<td>3.87***</td>
</tr>
<tr>
<td>Share Control</td>
<td>3.00</td>
<td>3.80</td>
<td>0.51</td>
<td>0.68</td>
<td>0.80</td>
<td>3.35***</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>3.62</td>
<td>4.18</td>
<td>0.50</td>
<td>0.49</td>
<td>0.56</td>
<td>3.68***</td>
</tr>
</tbody>
</table>

* p<0.05, **p<0.01 and *** p < 0.001

n=18

Table 2
*Average Item Mean Scores and Standard Deviations for Each Scale of Student’s Post-Actual and Preferred Perceptions of the Constructivist Learning Environment Survey*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean Post-Actual</th>
<th>Mean Preferred</th>
<th>Standard Deviation Post-Actual</th>
<th>Standard Deviation Preferred</th>
<th>Mean Difference</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personal Relevance</td>
<td>3.94</td>
<td>4.30</td>
<td>0.52</td>
<td>0.48</td>
<td>0.36</td>
<td>2.41</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>3.93</td>
<td>3.82</td>
<td>0.39</td>
<td>0.50</td>
<td>-1.10</td>
<td>0.71</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>4.37</td>
<td>4.37</td>
<td>0.46</td>
<td>0.46</td>
<td>0.00</td>
<td>1.76</td>
</tr>
<tr>
<td>Share Control</td>
<td>3.80</td>
<td>4.18</td>
<td>0.68</td>
<td>0.50</td>
<td>0.38</td>
<td>2.08</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>4.18</td>
<td>4.47</td>
<td>0.49</td>
<td>0.48</td>
<td>0.29</td>
<td>2.22</td>
</tr>
</tbody>
</table>

Overall, the results implied that the intervention based on the constructivist teaching approach can improve the learning environment in the Health Science classroom. This is clear in Figure 1.
Figure 1. Average mean scores of student’s perceptions of pre-actual, preferred and post-actual for each scale of the Constructivist Learning Environment Survey.

The qualitative data supported the assertion that a constructivist learning approach can improve the students’ perceptions of their constructivist learning environment in Health Science classrooms as in the following student opinions.

This teaching method improves the learning environment. We are enjoying learning, especially, playing the game about AIDS transmission, have a field trip into the community and the hospital.

I think that the constructivist teaching approach can create a relaxing learning environment. I feel free to tell the teacher or my friends about what I am thinking or how I am feeling.

There is no pressure and I am very happy to learn in this class. I think this new approach can improve our learning environment and also help us to have effective learning outcomes.

The student’s satisfaction of improving learning environment based on a constructivist learning approach.

The results show that the students who were involved in this action research process were satisfied with a constructivist learning approach used to attempt to improve learning environment. They stated that these learning activities were very interesting and provided increased variety dimensions in their learning. For example, encouraged them to actively participate, take responsibility for their own learning, and develop their higher order thinking skills as confirmed in the following comments:

We are enjoying learning because there are many activities and it makes a good learning environment, better than in the traditional classroom.

In a constructivist learning activities, we have learn from many sources, not only from the lecturer or text. We also learned form the website, discussed with our friends, having a field trip, interviewing an HIV infected person, and talking to the guest. I think these methods made a better learning environment than traditional teaching.

The learning activities was very interesting and exciting. It was create a great enthusiastic atmosphere for learning.

The group process can improve a good relationship with our peers. I also developed my social skill in this class. I think that if we have a good relationship in the class, so the atmosphere will enabling us to have an effective learning.

These new learning activities helped us to improve our self-confidence and felt relaxed when expressing my opinions and presenting to the class. When each student felt relax, therefore the class atmosphere is relaxed too.
In conclusion, the qualitative results indicate that the students’ are satisfied in a constructivist learning approach and they believe that this approach did improve their learning environments and learning achievement.

Conclusion

This classroom action research was aimed at improving learning environments in a Health Science class in Thailand through the use of the CLES and a constructivist approach. The learning environment is very important in the teaching and learning process and has a considerable effect on students’ learning outcomes. The CLES was used in this action research as a valid tool for assessing students’ perceptions of their Health Science learning environment at undergraduate level in Thailand. The results from the CLES were then used as a guideline for developed a new constructivist teaching strategy designed to bring about improving Health Science learning environment. Then, evaluating the success of the intervention by re-assessing of the CLES. The ATAQ and the SKAT were used to assessing students’ learning achievement. The results indicated that a constructivist learning approach was effective in developing learning environment in health science class in Thailand. The results of the CLES also shows that this new approach can be improve students’ perceptions on their learning environments in health science class. Furthermore, this approach can be developed their knowledge about AIDS and improving their attitudes toward AIDS. Finally, it seems that they are satisfied in this learning approach. Therefore, the teachers and health educators in Thailand can use a constructivist learning model to bring about improvement in learning environment and students’ achievement in their classes.

REFERENCES

ABSTRACT
The aim of this paper is to share experiences and lessons from a professional development model used to empower Biology, Mathematics, Chemistry, Computer Science and Physics Educators in South Africa through distance education. The project ran from 2001 to 2004 in two rural provinces of South Africa. With respect to the content, the model was focused on addressing deeper understanding, misconceptions, creating high order thinking and removing educator’s anxiety towards Science. The process was multi-faceted comprising face to face interactions, tutorial letters, readers, assignments and self-reflective inquiry learning. Recognition of prior learning was conducted through group interviews and pre-tests before modules were developed in the above areas. They were underpinned by the constructivism paradigm and based on outcomes based education. The Modules were written to develop content knowledge as well as pedagogical content knowledge. The mode of delivery was by distance education that comprised a tutorial letter, 2 contact workshops and 4 compulsory assignments. Formative and summative assessments were used to evaluate the performance of the educators. Qualitative and quantitative methods of research, including action research, focus group interviews and semi-structured interviews, were used in finding evidence based results that were integrated into the professional development model. However, the professional development process was constrained by several challenges, similar to those prevalent in other African rural schools, such as lack of infra-structure, poverty and impact of HIV/AIDS. Findings revealed a professional development model that encompasses the holistic development of the educators at four levels; the environment, the “self”, content knowledge and pedagogical content knowledge. Lessons learnt included the need for a holistic professional development model that takes cognizance of the resource poor rural African contexts. This holistic model integrated content knowledge, pedagogy, reflection and inquiry, leadership development and encompasses both face to face and distance education. Such a model would be beneficial to other African countries that encounter constraints in Science education especially in the context of African Renaissance.

Key words: Science education; Holistic model; Professional development; Distance education; African Renaissance; African context.

INTRODUCTION
The aim of this paper is to propose a professional development model that would empower Biology, Mathematics, Chemistry, Computer Science and Physics Educators in Africa through distance education. The proposition is based on experiences and evidence from a project ran from 2001 to 2004 in two rural provinces of South Africa. This paper focuses on the following research questions: What is the best model for developing Science Teachers in an African Context? What is the impact of professional development through distance education on the teaching practices of rural Science teachers?

To answer these questions it is vital to have a brief background on the Educational systems in Africa. Education systems in Africa are undergoing a dynamic change from traditional “chalk and talk” to Outcomes Based Education (OBE). This was revealed to the author through a survey on the status of Educational publishing commissioned by the African Union in 2007. In Eastern Africa, professional development of Teachers is facing challenges resulting from the political decisions of providing free education for all children. The Educators are over burdened and find no time for professional development outside the classrooms. Uganda and Kenya historically followed the British Education systems. Currently the two countries are completing curriculum reforms that will require the Science teachers to undergo professional development.

In West Africa, the Francophone countries followed the French Educational systems and also need professional development just as much as their fellow counterparts in the rest of Africa. The pertinent question is what challenges are prevailing in the context within which the professional development has to take place and what the best Model would be. In Southern Africa, the historical impact of apartheid is being felt among the previously disadvantaged Science Educators and within the schools. Prior to 1994, South Africa, like Namibia suffered the inequitable policies and practices of apartheid that left blacks in poverty unlike their white counterparts (Ottevanger, Macfarlane & Clegg,, 2005). As Welch (2002) points out, the teacher education system was
characterized by segregation and fragmentation. It was totalitarian, dictatorial, bureaucratic and controlled the curriculum to such an extent that black teachers spent only 3 years in the colleges while their white counterparts were educated at degree level for four years. This kind of repressive teacher education system was backed by policies like the Bantu Act of 1953 that produced mass schooling for blacks aimed at social control and subservient roles. The teachers were trained in departmental education centres, the so called homeland teacher and professional training centres.

The Education system or context prior to 1994 provided inadequate levels of training for black teachers. Few schools were built in the rural areas designated for blacks, coloureds and Indians. For the disadvantaged groups, there teacher colleges concentrated on content rather than pedagogy with disastrous consequences on students (Cohen, 1994).

Another peculiar comparison with the other education systems was the division of subjects into standard and higher grade unlike in East Africa. The majority of previously disadvantaged people took subjects at standard grade (Mathematics and Sciences) and accordingly could not join Universities. Coupled with the ill preparation of Science teachers (many did not conduct any experiments in their training) students were desolate and unable to perform at the peak of their potential.

The new system of education proposed to be just and equitable to the majority. It is also based on the principles of social responsibility designed to empower all individuals (National curriculum statements, 2005).

With the change of Government in 1994, the new Government was charged with the responsibility of providing education reforms (Department of Education of South Africa, 1996). This started with the introduction of a new curriculum the curriculum 2005 embedded in constructivism and outcomes based education (OBE). The challenge for the past decade was primarily the unification of Indian, coloured, black and white educational systems that had been separated in organization, funding and administration. The schools that were white only or ‘Model C’ are comparable to those in Europe while those previously disadvantaged are still wanting in resources. It is under these circumstances that professional development finds it’s self. The previously disadvantaged Science teachers also lack the necessary resources compared to their white counter parts in the ‘Model C’ schools. The Model I propose will focus on the previously disadvantaged teachers in rural settings. These are similar to many sub-Saharan rural schools. They are characterized by lack of resources; lack of roads, electricity, water, laboratories among other things.

Despite the education reforms, the professional development of Science educators remains a challenge in Africa. It is my view based on experience in Africa that we need to re-think the appropriate Models of professional development in Africa because the teacher’s needs, environment, classroom environment and personal development are different. It is against this background, that the holistic model is proposed.

**APPROACH**

A mixed methods approach consisting of both quantitative and qualitative strategies was used, including: document analysis; semi-structure interviews; focus-group discussions, questionnaires, site-visits, action research (Raubenheimer and Myka, 2005) and classroom observations. A one-year module was designed in response to the constraints identified by these rural teachers.

**Modes of Delivery**

The modules for each of the subjects (Mathematics, Biology, Chemistry, physics and computer science) were developed in response to constraints identified by rural teachers. They were offered through distance education with four compulsory assignments and a journal as completion requirements. Contact interactive sessions were conducted in form of workshops in locations near the teachers. Formative and summative assessments were used for evaluation.

The teachers who had to be practicing to be enrolled, had to complete a questionnaire about their qualifications, prior experiences with the Science subjects (Biology, Mathematics, Computer studies and Physics and Chemistry) as well as record their professional attitudes, conduct and teaching experiences in rural settings.

The content knowledge and pedagogical content knowledge (PCK) needs of the teachers was addressed through the module.
The Instrument

Questionnaires were designed to measure the professional attitudes of the Science teachers. They were administered to them during the school visits/contact sessions and collected immediately where possible. Some questions related to professional development were based on their understanding of what should be expected of a teacher. They were asked to write whether they thought it would be a reasonable thing to expect a teacher to do the following and how often:
(a) to write a lesson plan (b) to attend professional development during vocations or at weekends; among other professional conduct themes.

Models used in professional development of Science Teachers in South Africa

The models used in professional development of Science Teachers in South Africa and indeed in East and West Africa, fall under two broad categories, namely the cascade model and the cluster model. A combination of different models is used in the majority of cases (Susan Loucks-Horsley et al., 2003). Although several models have been used, the one so far that is practiced the most in South Africa is the so-called “cluster” model. A few schools are selected in the neighbourhood (called districts) of each other. Teachers meet at least once a month. The professional development is facilitated by subject advisors. The teachers in turn, train others using a team approach in a cascade-like model manner during meetings. They, for instance, discuss teaching strategies, difficult topics, examinations, experiments and the implementation of the curriculum. The cluster model allows teachers to establish networks among colleagues and exchange information. In addition, workshops are held to improve content knowledge and Pedagogical content knowledge (PCK) for each subject. The cascade model, on the other hand utilizes the training of trainers who then workshop other teachers in the respective subject areas. The major problem with this model is the loss of information as the cascade goes down the ladder.

The educational theory underlying the professional development is constructivism. Under this theory, the outcomes based education (OBE) system is being implemented in South Africa. Several reports (Van der Horst and McDonald, 1997; Jansen and Christie, 1999) on OBE have indicated challenges which the author deals with in relation to professional development in another article.

Case studies on Science education in rural areas and in relation to C 2005 implementation reported by Rogan and Colleen (2004) showed many misconceptions and the fact that the teaching in rural areas was still under the traditional chalk and talk. Outcomes-based education focuses on the achievement of outcomes rather than teacher input in terms of syllabus content (Department of Education, 1997). According to Rogan (2004) the curriculum implementation of C20005 (between 1998-2002) revealed content knowledge as the focus of the class room discourse. The emphasis was on group seating and on the active role of learners. He points out that “active” is not “productive” as teachers pointed out—they liked the learner-centeredness. The Science and mathematics teacher’s perceptions and misconceptions on the Curriculum (Colleen, 2004) revealed that teachers thought that there was a lowering of standards in C2005; although it was not a wide concern among teachers. They were more nervous about not answering questions posed under the curriculum 2005 environment. Curriculum 2005 also had confusing terminology and much anxiety was associated with assessment.

Rogan and Grayson (2003) provide a theoretical frame work to undertake theory-based research on curriculum implementation based on school development, Educational change and science education. They proposed three constructs namely profile of implementation, capacity to innovate and outside support. The model is plausible in many instances. What it does not do, however, is to expand on the attributes of the rural teachers and the analysis of rural contexts that many of the previously disadvantaged schools find themselves. The environment in rural areas, a context similar to the rest of Africa, was characterized by lack of infra structure, rampant poverty, transport problems for teachers and learners and negative impacts of diseases such as HIV and AIDS. These contexts are bound to have an influence on the Science Education and curriculum implementation, and definitely on the professional development of the teachers.

Theory of Learning

Although the design of professional programmes takes into account the different theories of learning and cognitive learning styles of prospective educators, it is the constructivist approach to learning that is most apparent in South Africa, particularly with the introduction of Out Comes Based Education (OBE). The learning experience becomes meaningful as educators take active part in constructing meaning through interaction with various study materials, workshops, experts and fellow educators. Educators are then challenged to confront,
understand and apply new concepts. Several reports on OBE, however, have shown that professional development in an OBE system poses many challenges (Jansen & Christie, 1999).

I will argue that professional development models imported to Africa from northern/western countries are unsuitable for the context. There is need to re-think these models to make them relevant and appropriate for African Science teachers. This argument is in agreement with Johnson, Monk and Hodges (2000) who discussed differential distribution of opportunities for professional development of Science teacher in post-apartheid South Africa. They reported that the north/western ideas about teacher change and development are poorly suited to the previouly disadvantaged teachers.

Similarly the theoretical frame works underpinning the professional development need to be innovative. I propose theories that take into consideration the stressful past and coping mechanisms related to race, colour and gender. Theories of human development psychology that underpin coping mechanisms, stress, and poverty be incorporated.

The theories of human development attempt to put meaning to responsive coping methods or correct problem-solving mechanisms of people (Spencer, Dupree, Phillips & Cunningham, 1998; Spencer et al., 1997). They reveal that across the course of life, experiences in different cultural context (e.g. home, school peer group and community) influence how one perceives oneself, meaning that there is a relationship between life experiences and self-esteem. In South Africa and the rest of Africa teacher’s roles have changed from educators into lay counselors particularly in the HIV/AIDS pandemic; managers, leaders. The teachers need personal and professional development to cope. At the basis of this need is the self-worth and self esteem of the teacher particularly in the context of poverty and endemic diseases.

To put a single theoretical frame work that eludes the ethnic-specific challenges generally confronted by the previously disadvantaged science educators would conceivably be prejudicial. Often, emerging patterns are explained by simplistic, none contextualized unidirectional and monocultural, mostly Eurocentric analyses that often omit the theories of human development and the relationship between risk and stress contributors and coping methods within the South African context. In the context of rural educators, it would be unjust to ignore developmental psychopathology that explains eco-cultural experiences associated with race and colour status and coping with chronic poverty observed by Spencer et al.(1997).

The Holistic Model

The Holistic model comprises content, environment, “self” and Pedagogical content knowledge (Fig. 1).

Content

With respect to the content, the model was focused on addressing deeper understanding, misconceptions, creating high order thinking and removing educator’s anxiety towards Science.

Process

The process was multi-faceted comprising face to face interactions, tutorial letters, readers, assignments and self-reflective inquiry learning. Recognition of prior learning was conducted through group interviews and pre-tests before modules were developed in the above areas. They were underpinned by the constructivism paradigm and based on outcomes based education. The Modules were written to develop content knowledge as well as pedagogical content knowledge (PCK).

Mode of delivery

The mode of delivery was by distance education that comprised a tutorial letter, 2 contact workshops and 4 compulsory assignments. Formative and summative assessments were used to evaluate the performance of the educators.

Distance education allowed the educators to attend in-service training in their own time. They used their classroom practice and applied knowledge immediately as all participants were practicing teachers. The educators were partnered with other educators in the communities which improved peer education. The model provided activities designed to enhance “hands-on” knowledge, teaching skills and understanding that led to change in thinking and impacted on class room practice. Above all, the distance education ensured that teachers
were not taken out of their class rooms. The contact sessions were used to clarify issues, address misconceptions, as a net working forum and they provided a bond among lecture and the teachers.

Figure 1 Holistic Model for Professional development of Science teachers in Africa

The Holistic model integrates the “self” personnel development of the teacher linked to the teaching profession as a “practice”. The attitudes of the teacher and professional conduct are vital; they are probed at the beginning of the professional development and later in the year. Observations are made to evaluate how attitudes and teaching change. Reflection is made through the journal kept by the teachers. The PCK and the content knowledge are added in the study guides in each topic. The Environmental contexts where teachers are based are taken into consideration when designing the professional development.

Reflection
The concept of self reflection was integrated in the model by individual journals kept by the educator. This encouraged the educators to examine their beliefs about the subject first before improving their practice. The quality of the model was also based on improving the profession. To this end, a questionnaire on professional conduct and attitudes on behaviour was instituted during the programme. Evaluation data included analysis of the outcomes based on evidence collected from the exam marks; photocopies of the assignments; contact workshop evaluation sheets; and evaluation sheets contained in the study guides, interviews and reflective journals.

Findings revealed a professional development model that encompasses the holistic development of the educators at four levels; the environment, the “self”, content knowledge and pedagogical content knowledge. Lessons learnt included the need for a holistic professional development model that takes cognizance of the resource poor rural African contexts.
Distance education allowed the educators to attend in-service training in their own time. They used their classroom practice and applied knowledge immediately as all participants were practicing teachers. The educators were partnered with other educators in the communities which improved peer education. The model provided activities designed to enhance “hands-on” knowledge, teaching skills and understanding that led to change in thinking and impacted on class room practice.

The concept of self reflection was integrated in the model by individual journals kept by the educator. This encouraged the educators to examine their beliefs about the subject first before improving their practice. The quality of the model was also based on improving the profession. To this end, a questionnaire on professional conduct and attitudes on behavior was instituted during the programme. Evaluation data included analysis of the outcomes based on evidence collected from the exam marks; photocopies of the assignments; contact workshop evaluation sheets; and evaluation sheets contained in the study guides, interviews and reflective journals.

This holistic model integrated content knowledge, pedagogy, reflection and inquiry, leadership development and encompasses both face to face and distance education. Such a model would be beneficial to other African countries that encounter constraints in Science education especially in the context of African Renaissance.

Constraints of the Holistic Model

The Constraints are mostly embedded in the contexts in Africa. The impact of HIV/AIDS on the educational sector is devastating. Teachers need counseling skills and to be counseled themselves. The rampant poverty meant that some could not afford the transport costs to the training venues where workshops were held. Lack of resources in the schools for instance laboratories meant that the experiments were limited and some times a challenge to hold.

Solutions to the Professional Development Constraints suggested

- Networking during the workshops
- Science kits provided to the teachers and demonstrations held
- Subsidized text books were provided to the teachers. During the programme, a nominal fee of R 100 (US$14) was charged for the recommended text books. The teachers were given the option to pay in two installments of R 50 per month.
- Mentorship and coaching for the teachers by more experienced ones or teacher educators including retired ones (volunteer basis)

Discussion

The proposed holistic model is relevant for Africa. Previously many professional development models were based on Western/Northern experiences and ideas and were simply imported because they had worked in the West. Johnson, Monk and Hodges (2000) reported the differential distribution of opportunities for professional development of Science teachers in post-apartheid South Africa and revealed that the north/Western ideas about teacher change and development are poorly suited to modeling practices and challenges for those who were previously disadvantaged.

“The environment in which teachers work-physical, social and political-act to select a more limited repertoire of behaviour that those providing that some might imagine” They argue for evolutionary ideas on teacher change and development that offer a more effective model of the constraints under which the teacher works.

Given the African Renaissance, there is new thinking about how Africa is and where it should go; Many African countries are changing their educational systems form traditional talk and chalk to outcomes based education (OBE) (DOE, 1995; 199; Rogan, 2007). The challenge, however, is the lack of understanding of the real contexts. Science teachers are different in that the set of circumstances are different and the need s are different form those of the USA and the UK where most Models are taken from.

I argue that a holistic model that encompasses content knowledge, PCK, “Self” professional development and that takes cognizance of the rural –resource poor settings be instituted in Africa. The model should be mixed in approach with distance education, contact sessions, reflection and inquiry learning at the core of the designs.
Many of the current models are poorly matched with the needs of the Science teachers and there is urgent need of re-thinking the strategies. The Renaissance here also brought into the concept of multi-, inter-, and trans-disciplinary that brings different disciplines into the professional development of the teachers. Since a teacher is also a counselor for HIV/AIDS, he/she needs skills to cope. The holistic model therefore forms the basis upon which the future professional development should be designed for Africa.

Acknowledgement

The author wishes to thank the Carnegie Foundation of New York that funded the Centre for Improvement of Science and Technology Education (CIMSTE), UNISA through which this professional development was conducted. Professional inputs form colleagues Mrs. Bridget Davis (Chemistry); Mr. Gerit Stolz (Mathematics); Mrs. Jean Kriek (Physics); Katherine ( Computer Science); are acknowledged. Research support from Prof Andile Mji and Mrs Mapula Ngoepe; Administration support form Ignatius Dire and All the Science teachers are duly acknowledged.

References


ABSTRACT

The first purpose of the study was to provide validation information of two questionnaires that were modified and translated into the Thai language, namely, the Science Laboratory Environment Inventory (SLEI), and the Attitude to Biology Class (ABC). A second purpose was to determine students’ perceptions of laboratory learning environments and their attitudes to biology classes in secondary schools in Thailand. A sample of 1,194 students from 37 biology classes in 37 schools completed the two questionnaires. The results of the study showed that most students in secondary schools of Thailand have moderately positive attitudes to their biology class. In biology laboratories, they perceived the environments as employing good student cohesiveness, less open-endedness and integration of the theory and practical, the rules were not clear and the materials were not good and insufficient. There were differences between students’ actual and ideal perceptions of laboratory learning environments. Students preferred a biology laboratory environment with higher levels on the scales of Open-Endedness, Integration, Rule Clarity, and Material Environment but not Student Cohesiveness.

INTRODUCTION

The past three decades, much attention has been focused on the development and use of instruments to assess the quality of the classroom-learning environment from the perspective of students. However, these instruments were developed for non-laboratory learning environments. Consequently, Fraser, McRobbie, and Giddings (1993) developed a new instrument to investigate student perceptions of laboratory learning environments, in both Class and Personal Forms, called the Science Laboratory Environment Inventory (SLEI).

McRobbie and Fraser (1993a) used the SLEI in the first investigation between laboratory environment and student outcomes. The findings showed strong positive associations with both students’ cognitive and attitudinal outcomes. Furthermore, they used the SLEI to develop a typology of science laboratory learning environments (McRobbie & Fraser, 1993b). The finding showed that the elementary schools had a more favourable school environment than high schools, district school or secondary colleges on most of scales.

Harrison, Fisher, and Henderson (1997) used the SLEI to study students’ perception of senior high school biology, chemistry and physics laboratory learning environments with 370 students in 20 classes in Tasmania, Australia. The findings showed the biology students had the lowest scores on the scale of Open-Endedness.

In Thailand, there are few research studies concerning the learning environment of science classes and there is little evidence of teachers’ use of questionnaires in the schools.

The initial version of SLEI contained 72 items in eight scales. After field-testing and validity and reliability testing, the final version consists of 35 items in five scales (Fraser, McRobbie, & Giddings 1993) as presented in Table 1.

This instrument was initially developed in a Class Form to measure learning environment in science laboratories (Fraser, Giddings & McRobbie, 1992, 1995). It consists of 35 items validated with both students in schools and universities from six countries: USA, Canada, Australia, England, Nigeria, and Israel. The Personal Form, however, was developed from that Class Form (Fraser, Giddings, & McRobbie, 1995). Notably, not in Thailand. It was decided to use the Personal Form in this study because the researcher believed that the Thai students would understand the individual aspects in the meaning of the items in this form better than they would in the Class Form. The Personal Form has been validated in studies involving students in Australian secondary chemistry classes (Fraser, Giddings, & McRobbie, 1995), in Singapore (Wong & Fraser, 1995) and Brunei (Riah & Fraser, 1997b). Importantly, the validity and usability of this form was confirmed with Australian secondary biology students (Fisher, Henderson, & Fraser, 1997). Moreover, this form had been used in other translated versions in other countries where English is not the mother language.
Table 1
Descriptive Information and Sample Item for Each Scale of the SLEI

<table>
<thead>
<tr>
<th>Scale name</th>
<th>Description of scale</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness (SC)</td>
<td>Extent to which students know, help and are supportive of one another.</td>
<td>I get on well with students in this biology laboratory. (+)</td>
</tr>
<tr>
<td>Open-Endedness (OE)</td>
<td>Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation.</td>
<td>There is opportunity for me to pursue my own biology interests in this laboratory class. (+)</td>
</tr>
<tr>
<td>Integration (I)</td>
<td>Extent to which the laboratory activities are integrated with non laboratory and theory.</td>
<td>What I do in our regular biology class is unrelated to my laboratory work. (-)</td>
</tr>
<tr>
<td>Rule Clarity (RC)</td>
<td>Extent to which behaviour in the biology laboratory is guided by formal rules.</td>
<td>My biology laboratory has clear rules to guide my activities. (+)</td>
</tr>
<tr>
<td>Material Environment (ME)</td>
<td>Extent to which the biology laboratory equipment and material are adequate.</td>
<td>I find that the biology laboratory is crowded when I am doing experiments. (-)</td>
</tr>
</tbody>
</table>

Items designed (+) are scored 1, 2, 3, 4, and 5 respectively for the responses Almost Never, Seldom, Sometimes, Often, and Very Often. Items (-) are scored in the reverse manner. The 35-item version of SLEI contains both of positive and negative items as shown in Table 2. The negative items needed to be reverse scored.

Table 2
Positive and Negative Items in Each Scale of the SLEI

<table>
<thead>
<tr>
<th>Scale</th>
<th>Positive Items</th>
<th>Negative Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness (SC)</td>
<td>1, 11, 16, 21, 31</td>
<td>6, 26, 7</td>
</tr>
<tr>
<td>Open-Endedness (OE)</td>
<td>2, 7, 12, 17, 22, 32</td>
<td>27</td>
</tr>
<tr>
<td>Integration (I)</td>
<td>13, 18, 28</td>
<td>3, 8, 23, 33, 7</td>
</tr>
<tr>
<td>Rule Clarity (RC)</td>
<td>4, 14, 19, 29, 34</td>
<td>9, 24, 7</td>
</tr>
<tr>
<td>Material Environment (ME)</td>
<td>10, 30, 35</td>
<td>5, 15, 20, 25, 7</td>
</tr>
</tbody>
</table>

In Australia, Henderson, Fisher and Fraser (2000) studied associations between students’ perception of their laboratory learning environments and their attitudinal outcome including attitude toward class and attitude toward laboratory work. The SLEI was administered to 489 students from 28 senior biology classes in eight schools in Tasmania, Australia. The findings showed that all SLEI scales, except the Open-Endedness scale, were associated with attitudinal outcomes. The Integration scale was the scale most strongly associated with attitudinal outcomes when other SLEI scales were mutually controlled.

The correlation between students’ attitude and classroom learning environment is necessary for effective teaching and learning. Therefore, it was decided to use a measure of students’ attitude to biology classes, in this study in Thailand. To accomplish this, the Attitude to Biology Class questionnaire (ABC) was developed based on the Test of Science Related Attitudes (TOSRA) (Fraser, 1981).

The ABC is a questionnaire used to assess students’ attitudes to biology classes in order to investigate associations with scales of the SLEI. It consisted of seven items drawn from items in the attitudinal questionnaire, TOSRA. The TOSRA was developed by Fraser (1981) to measure students’ attitude in secondary science classes. It consisted of 70 items within seven attitude scales based on Klopfer’s rationale: Social Implication of Science, Normality of Scientists, Attitude to Scientific Inquiry, Enjoyment of Science Lessons, Adoption of Scientific Attitudes, Leisure Interest in Science, and Career Interest in Science.

Fisher, Henderson, and Fraser (1997) later added one more item. Therefore, this study used a seven-item from Enjoyment of Science Lessons scale that has been previously validated. To measure students’ attitude in biology classes in Thailand, it was translated into a Thai version to ensure its suitability for Thai students.
However, the original version was developed for science classes, therefore replacing the word ‘science’ with the word ‘biology’ provided a more suitable wording for each item in this study.

**METHODOLOGY**

The objectives of this study were to:

1. provide validation information of two questionnaires that were modified and translated into the Thai language, namely, the Science Laboratory Environment Inventory (SLEI), and the Attitude to Biology Class (ABC).
2. determine students’ perceptions of laboratory learning environments and their attitudes to biology classes in secondary schools in Thailand.

The sample of this study was composed of students who studied in biology classes at the grade 10 level of secondary schools in Thailand. The total sample involved 1,194 students who completed questionnaires in their biology classes. The instruments used in this research were the SLEI and the attitudes to biology were measured with a scale based on an adaptation of the Test of Science Related Attitudes (TOSRA) (Fraser, 1981). It was adapted, specifically for this subject, and named Attitude to Biology Class (ABC). Students completed two forms of the SLEI. The first form was the Actual Form used to assess students’ perceptions of their current laboratory environments. The second was the Preferred Form that was used to ask students to rate their preferred laboratory environment.

The questionnaires were Australian versions that were modified and translated into Thai versions. The SLEI and the ABC consist of 35 items and 7 items, respectively. Students indicated their perceptions on response sheets, using a five-point Likert scale format. The response sheets of the SLEI, and ABC use a 5-point Likert scale format. Scoring involves the numbers 1, 2, 3, 4, and 5 for the responses from Never to Always, for the ABC and Almost Never, Seldom, Sometimes, Often, and Very Often. However, some items had a negative meaning and the scoring was reversed. Students who responded to the questionnaire were asked to put the student identity number of their classes and their names if they preferred.

For examination of the validation of questionnaires, Cronbach alpha reliability coefficients as indices of scale internal consistency were estimated. Mean correlations between the scales for the SLEI were also investigated. Analysis of variance (ANOVA) was used to determine the ability of each of the scales of the SLEI to differentiate between the perceptions of students in different classes. Simple and multiple correlations were computed to find associations between each of the SLEI scales and each of the SLEI scales and attitude to biology.

The difference between the two means of the Actual and Preferred forms was tested for statistical significance using $t$ tests and effect sizes.

Gender, school situation and school size differences between the Actual Forms were examined using a one-way multivariate analysis of variance (MANOVA) with the set of SLEI scales as dependent variables. When the $F$ test was found to be statistically significant ($p<0.05$), a univariate analysis of variance (ANOVA) was computed.

An Analysis of Variance (ANOVA) was used to compare the means of more than two groups of an independent variable. If the ANOVA result of more than two values, such as three school sizes, was significant, post hoc (Tukey) analysis was employed to determine between which of the variables the difference occurred.

**RESULTS**

**Validation of the SLEI**

Statistics relating to the Actual Form of the SLEI: internal consistency, discriminant validity and ability to differentiate between the perceptions of students in different classes are reported as shown in Table3.
Cronbach alpha reliabilities again were calculated to determine the internal consistency of the scales of the SLEI. The alpha reliability for the Actual Form of the SLEI shows the lowest values of 0.52 (Open-Endedness) and 0.61 (Rule Clarity) when using the individual student as the unit of analysis, and 0.84 (Open-Endedness) and 0.86 (Rule Clarity scale) when using the class mean as the unit of analysis.

It was clear that the reliability of these scales could be improved by deleting some items. Item 6 of the Open-Endedness scale, and items 2 and 5 of the Rule Clarity scales were deleted. Therefore, the total number of items in the Thai version of the SLEI was 32 as shown in Table 4. Once the selected items were deleted, the Cronbach alpha reliabilities were again calculated as shown in the column After in Table 3. The Table 3 shows that the alpha reliabilities of the Actual Form of the SLEI scales ranged from 0.59 to 0.69 when using the individual student as the unit of analysis and from 0.70 to 0.86 when using the class mean as the unit of analysis.

These figures are similar to those given by Fisher, Henderson, and Fraser (1995), who reported a range from 0.58 to 0.85 for the Actual Form when using the individual as the unit of analysis.

In keeping with previous learning environment validation studies, information supporting the discriminant validity through the mean correlation of a scale with other scales was computed. The mean correlation of a scale with other scales ranged from 0.21 to 0.40 for the Actual Form of the SLEI (Table 3) when using the individual student as the unit of analysis. When using the class mean as the unit of analysis they ranged from 0.30 to 0.54 for the Actual Form (Table 3). These figures indicate that the SLEI measures distinct aspects of the laboratory environment, although somewhat overlapping.

The $\eta^2$ statistic was calculated to determine whether the Thai version of the SLEI was capable of differentiating between the perceptions of students in different classes. The $\eta^2$ value ranged from 0.09 (Student Cohesiveness) to 0.18 (Open-Endedness) for the Actual Form. Table 3 also indicates that each SLEI scale differentiated significantly ($p < 0.01$) between classes.
Overall, the results suggested that the Thai version of the SLEI is a valid and reliable questionnaire for use in investigating students’ perception of learning environments in biology laboratories in secondary schools in Thailand.

Validation of the ABC (The attitudes to biology classes)

The ABC used to assess student attitudes to biology classes in this study consisted of seven items. This scale was found to have an alpha reliability of 0.83 with the individual student as the unit of analysis. This figure indicates that this scale in its Thai version has acceptable internal consistency.

Student perceptions of their biology laboratory learning environments

The class means and standard deviations for student responses to both versions of the SLEI were calculated and are shown in Table 5. For facilitating comparison between the actual and preferred student responses, the results are presented graphically in Figure 1. It shows that students prefer a biology laboratory environment with higher levels on four of the scales; Open-Endedness, Integration, Rule Clarity and Material Environment. With consideration to the effect size, it was found that there were big differences in Rule Clarity and Material Environment, medium in Open-Endedness, and a small effect size in Student Cohesiveness and Integration, as shown in Table 5.

Table 5
Scale Mean and Standard Deviations for Actual and Preferred Forms of the SLEI

<table>
<thead>
<tr>
<th>Scales</th>
<th>Actual Mean</th>
<th>S.D.</th>
<th>Preferred Mean</th>
<th>S.D.</th>
<th>(Preferred-Actual) Mean</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness (SC)</td>
<td>4.00</td>
<td>0.55</td>
<td>4.04</td>
<td>0.53</td>
<td>0.04</td>
<td>0.07</td>
</tr>
<tr>
<td>Open – Endedness (OE)</td>
<td>3.40</td>
<td>0.53</td>
<td>3.67</td>
<td>0.52</td>
<td>0.27***</td>
<td>0.51</td>
</tr>
<tr>
<td>Integration (I)</td>
<td>3.59</td>
<td>0.55</td>
<td>3.70</td>
<td>0.62</td>
<td>0.11***</td>
<td>0.19</td>
</tr>
<tr>
<td>Rule Clarity (RC)</td>
<td>3.73</td>
<td>0.58</td>
<td>4.05</td>
<td>0.57</td>
<td>0.32***</td>
<td>0.97</td>
</tr>
<tr>
<td>Material Environment (ME)</td>
<td>3.45</td>
<td>0.63</td>
<td>3.93</td>
<td>0.65</td>
<td>0.48***</td>
<td>0.75</td>
</tr>
</tbody>
</table>

***p<0.00, **p<0.01, *p<0.05 (n = 1,194)

Figure 1. Differences between average item means of Actual and Preferred Forms of the SLEI.
Student perceptions of their attitudes to biology

The results showed that the average item mean was around 3.84 with a standard deviation of 0.55. The minimum and maximum scores were 3.59 and 4.41, respectively. Table 6 showed the number of students for each rating category score.

Table 6

<table>
<thead>
<tr>
<th>Rating Score</th>
<th>Almost Never (1.00-1.99)</th>
<th>Seldom (2.00-2.99)</th>
<th>Sometime (3.00-3.99)</th>
<th>Often (4.00-4.99)</th>
<th>Almost Always (5.00)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>2</td>
<td>55</td>
<td>579</td>
<td>527</td>
<td>31</td>
</tr>
</tbody>
</table>

The results indicated that students had positive attitudes towards their biology class as distinctively displayed in Figure 2.

Differences in attitudes to biology

Average means of students’ perception on attitude to biology classes were examined between gender, school situation, and school sizes. The F values were used to examine the statistical significances. When the F test of gender and school situation were found to be statistically significant (p < 0.05), univariate analysis of variances were computed. For school size differences, pos-hoc analyses were again used to determine between which schools these differences occurred.

Table 7 presents the average mean scores of students’ attitude to their biology classes. The results suggest that Grade 10 students in secondary schools in Thailand have a moderately positive attitude to biology class. There were differences between students’ attitudes according to gender, school situation and school size.
The results suggest that females had more favourable attitudes to biology than did males, and students in rural schools had more favourable attitudes to their biology classes than did students in the city schools. There was a difference of attitudes to biology class between students in small and medium schools. The students in medium schools have a better attitude to biology than do students in small schools. These results are depicted graphically in Figure 3.

Table 7
Average Mean and Standard Deviation of Students’ Perception on Attitudes to Biology Classes

<table>
<thead>
<tr>
<th></th>
<th>Average Mean</th>
<th>Standard Deviation</th>
<th>F value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (N = 424)</td>
<td>3.76</td>
<td>0.55</td>
<td>15.28***</td>
<td>0.24</td>
</tr>
<tr>
<td>Female (N = 770)</td>
<td>3.89</td>
<td>0.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>School Situation:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City (N = 419)</td>
<td>3.80</td>
<td>0.57</td>
<td>4.88*</td>
<td>0.13</td>
</tr>
<tr>
<td>Rural (N = 775)</td>
<td>3.87</td>
<td>0.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>School Size:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small (N = 330)</td>
<td>3.79</td>
<td>0.53</td>
<td>3.97*</td>
<td>-0.1*</td>
</tr>
<tr>
<td>Medium (N = 486)</td>
<td>3.89</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large (N = 378)</td>
<td>3.82</td>
<td>0.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Students</strong></td>
<td>3.84</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(N = 1,194)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***p<0.001, **p<0.01, * p<0.05
Note: S = small schools; M = medium schools; L = large schools

Figure 3. Mean differences between gender, school-situation and school-size on students’ attitude.
ASSOCIATIONS BETWEEN LABORATORY LEARNING ENVIRONMENTS AND STUDENTS’ ATTITUDES TO BIOLOGY CLASS

To examine associations between laboratory learning environments, and students’ attitude towards biology, simple correlations, multiple correlations and regression coefficients were analyzed using the individual student as the unit of analysis.

Table 7 shows the results of the simple correlation analysis between the SLEI scales and students’ attitude using the individual student as the unit of analysis. Statistically significant correlations (p<0.01) exist between students’ attitudes towards biology and three scales of the SLEI. There were no relationships with either the Student Cohesiveness or Integration scales. The significance level was p<0.01 for the Open-Endedness and Rule Clarity scales, and p<0.05 for the Material Environment scale.

Standard regression weights (β) were used to identify which of the five SLEI scales contributed to the variance in student attitudes when the other scales were controlled. The standard regression weights (in Table 8) suggest that no statistically significant relationships between laboratory learning environment and student attitude to biology class. The R^2 value indicates that only 1% of the variance in students’ attitudes of their biology class could be attributed to their perceptions of their biology laboratory learning environments.

<table>
<thead>
<tr>
<th>Scales</th>
<th>Mean</th>
<th>S.D.</th>
<th>r</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness (SC)</td>
<td>4.00</td>
<td>0.55</td>
<td>0.03</td>
<td>-0.02</td>
</tr>
<tr>
<td>Open – Endedness (OE)</td>
<td>3.40</td>
<td>0.53</td>
<td>0.08**</td>
<td>0.06</td>
</tr>
<tr>
<td>Integration (I)</td>
<td>3.59</td>
<td>0.55</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td>Rule Clarity (RC)</td>
<td>3.73</td>
<td>0.58</td>
<td>0.09 **</td>
<td>0.05</td>
</tr>
<tr>
<td>Material Environment (ME)</td>
<td>3.45</td>
<td>0.63</td>
<td>0.06*</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Multiple correlation R = .12** R^2 = .01

**p<0.01                     *p<0.05

CONCLUSIONS AND DISCUSSIONS

The results indicate that two instruments modified into Thai versions, the 32-item SLEI and the 7-item ABC were good valid instruments and can be used to investigate students’ perceptions in secondary schools in Thailand.

For the biology laboratory learning environments, the students in secondary schools in Thailand responded positively to student cohesiveness, but negatively to open-endedness and integration of the theory and practice. They considered the rules were unclear and the materials impracticable and insufficient.

They have a moderately positive attitude to biology class. Females had more favourable attitudes to biology than did males, and students in rural schools had more favourable attitudes to their biology classes than did students in the city schools. There was a difference of attitudes to biology class between students in small and medium schools. The students in medium schools have a better attitude to biology than do students in small schools. There were associations between biology laboratory learning environments and students’ attitude.

The results of the differences between the actual and preferred perceptions, Fisher and Fraser (1983b) who studied the person-environment fit research suggested that students could perform better when there is a close alignment of actual and preferred environment. So teachers and school should provide information of students’ perception and then provide an approach to make classroom environment better.

In my opinion as the first researcher, this study has provided a number of implications for further research. It is suggested that large-scale interviews should be considered for future research. This could provide qualitative data about learning environments in biology classes in Thailand.
REFERENCES


ABSTRACT

This paper reports on a study into the perceptions students have of the learning environment in Year 9 and 10 mathematics classrooms when the classes are streamed. The sample consisted of 581 students in Years 9 and 10 in 7 different Christian independent schools across Australia. The What is Happening in the Classroom (WHIC) inventory was used along with a qualitative analysis of interviews with a subset of participants. Results included: students in lower stream mathematics classes report significantly less positive perceptions of their classroom learning environments than students in upper stream mathematics classes, the areas rated most negatively by the lower stream students were in teacher support and task orientation, the areas rated most negatively by the upper stream students were in involvement and investigation, students in the upper stream often feel overworked and left behind whereas students in the lower stream are in some cases not encouraged to excel and fall into a fatalistic attitude of underachievement, even though the learning environment in upper streams was perceived by students to be more positive than lower streams, the desire for positive changes in the upper stream learning environment was more pronounced than in the lower stream. Another result of particular interest and concern was that lower stream perceptions of learning environment deteriorates from Year 9 to Year 10 whereas upper stream perceptions become more positive from Year 9 to Year 10.

INTRODUCTION

The question of whether it is a sound practice to stream students for academic ability in mathematics classes in the middle years of secondary school has been a matter of debate for many years. While there have been numerous studies which indicate that more able students achieve at a marginally higher level when placed in an ‘upper stream’ (e.g., Brewer, Rees & Argys, 1996; Hoffer, 1992; Venkatakrishnan & Wiliam, 2003), there has been little research done which shows the nature of the classroom learning environments in streamed classes as opposed to mixed ability classes and how this may influence the learning outcomes of the students, especially those placed in lower streams. What aspects of their learning environments do students see as causing them to feel the way they do about their mathematics classrooms?

This question is even more pertinent when one considers that in many cases Christian secondary colleges are small enough to have only two streams which means students will be placed into an upper stream or a lower stream.

The question may be asked as to why anybody would even question the practice of ability grouping, particularly when in NSW the mathematics curriculum is itself streamed, requiring middle secondary students to choose a particular level which in many cases leads logically on to specific mathematics options in the senior school. This study revealed enough data to encourage educators to reassess the practice of academic streaming in general.

If the question is asked of teachers as to why they support academic streaming in middle secondary mathematics, their standard answers are usually ‘it is easier and more efficient for the teacher’, ‘it helps students learn to their level and feel better about themselves’, it limits the amount of failure slower students may experience and feel’, it has ‘worked for years’.

DiMartino (2005) disputes each of these points. He believes that when the evidence of research is taken together, streaming doesn’t really help anybody. He points to studies that have shown that it is not possible to place students into groups based on ability and do it equitably or accurately. The history of research in this area also shows that students do not necessarily do better when put in classes of students with like ability. He also believes that the research shows a lower self-esteem for students in lower streams. In fact he can see no positive aspects of streaming. The logical conclusion to what he is saying is that streaming is polarising, creates elitism, sets low expectations for both lower stream students and teachers, wastes time, and encourages segregation.
Hoffer’s (1992) research showed that any academic gains from ability grouping are too small to be significant. Indeed placing students from a mixed ability class into an upper stream produces a weak positive net result while placing a student from a mixed ability class into a lower stream class produces a strong negative result. A study by Venkatakrishnan and Wiliam (2003) reports similar findings. While it was stated that streaming has different effects on different students, in general it was found that upper stream students did not receive a large advantage by being streamed, mixed ability students kept performing at their previous level and lower performing students were disadvantaged.

THE STUDY

This study reports on 581 Year 9 and 10 students in 36 different classes taught by 28 different teachers in 7 schools covering 4 states of Australia. All of these schools were Christian independent schools. The students were from upper and lower streams of mathematics classes as well as from mixed ability classes.

The students were surveyed using an instrument called the ‘What is Happening in this Classroom’ inventory (WIHIC). The participants were asked to respond to the 56 items categorized into 7 scales. They were asked to respond to each item twice – once for their perception of their current actual mathematics classroom learning environment, and again for their preferred classroom learning environment. A sample of questionnaire items can be seen in Table 1.

Around 5% of the students surveyed with the questionnaire were also interviewed by email and asked questions on issues that arose from the questionnaire. This was a new way to interview students, but proved to be successful perhaps because email is one of the most common ways students currently communicate. It was found that email communication eliminated some of the common roadblocks to interviewing students. These include: establishing trust, overcoming reticence, maintaining informality, avoiding assuming that children ‘know the answer’, overcoming the problems of inarticulate children, pitching the question at appropriate level, inadvertently giving non-verbal cues, avoiding children giving answers they think the interviewer wants to hear, avoiding the interviewer being seen as an authority spy or plant, keeping to the point, having students be open and honest despite peer-group pressure, or having students feel equal in importance to adults.

The seven scales of classroom environment perception that were measured in the survey were: student cohesiveness, teacher support, involvement, task orientation, investigation, cooperation and equity. One of the objectives of the study was to establish which of the scales most clearly differentiated lower stream students’ perceptions of their learning environments from upper stream students’ perceptions.

Because of the relatively small sample size used in this study it was important to calculate Cronbach’s Alpha Reliability Coefficient for scales of the WIHIC to check for internal consistency or reliability.
Table 1
Sample Items from the What is Happening in this Classroom Inventory Used in this Study.

<table>
<thead>
<tr>
<th>ACTUAL</th>
<th>PREFERRED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Cohesiveness</strong></td>
<td><strong>Teacher Support</strong></td>
</tr>
<tr>
<td>Almost Always</td>
<td>Often</td>
</tr>
<tr>
<td>1. I make friendships among students in this class.</td>
<td>1</td>
</tr>
<tr>
<td>9. The teacher takes a personal interest in me.</td>
<td>Almost Always</td>
</tr>
<tr>
<td>17. I discuss ideas in class.</td>
<td>Almost Always</td>
</tr>
</tbody>
</table>

Table 2 provides information for the WIHIC when used specifically with the present sample of mathematics classes. Statistics are reported for two units of the analysis, namely, the individual student’s score and the class mean score. It can be seen in the table that, as expected, the reliabilities for the class means for each scale were higher than the reliabilities for the individual student on each scale. Table 4.4 also shows that the range of Alpha Reliability figures for each of the different WIHIC scales ranged from 0.79 to 0.93 when the individual student was used as the unit of analysis and from 0.89 to 0.97 when the class mean was used as the unit of analysis. These are high reliabilities for all scales of the WIHIC when used with the present sample.

Table 3 shows the difference in the mean scores allocated to each scale by students. It can be seen clearly that while the upper stream had a more positive perception of their learning environment for every scale, the scales of teacher support and task orientation are the two scales that most clearly differentiate lower stream and upper stream students’ perceptions of their learning environments. The lower scores indicate the more positive perceptions.

Having established that upper stream students rate their classroom environment more positively than lower stream students, the differences between their current classroom rating and their preferred classroom rating were analysed by stream.
Table 2

Internal Consistency (Cronbach Alpha Coefficient) and Ability to Differentiate Between Classrooms for the WIHIC

<table>
<thead>
<tr>
<th>Scale</th>
<th>Unit of Analysis</th>
<th>Alpha Reliability</th>
<th>ANOVA Results (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>Individual</td>
<td>0.79</td>
<td>0.14*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.92</td>
<td></td>
</tr>
<tr>
<td>Teacher Support</td>
<td>Individual</td>
<td>0.91</td>
<td>0.31*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.97</td>
<td></td>
</tr>
<tr>
<td>Involvement</td>
<td>Individual</td>
<td>0.84</td>
<td>0.13*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.89</td>
<td></td>
</tr>
<tr>
<td>Task Orientation</td>
<td>Individual</td>
<td>0.84</td>
<td>0.18*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>Individual</td>
<td>0.89</td>
<td>0.14*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Cooperation</td>
<td>Individual</td>
<td>0.89</td>
<td>0.11*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>Individual</td>
<td>0.93</td>
<td>0.25*</td>
</tr>
<tr>
<td></td>
<td>Class Mean</td>
<td>0.97</td>
<td></td>
</tr>
</tbody>
</table>

n = 581 in 36 classes  *p<0.001

Table 3

Summary Table Showing Statistics Which Compare Streams with Actual Scales of the WIHIC

<table>
<thead>
<tr>
<th>Scale</th>
<th>Upper or Lower</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>Upper Stream</td>
<td>1.96</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.07</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.11</td>
<td>0.04</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>Upper Stream</td>
<td>2.40</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.67</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.27</td>
<td>0.03</td>
</tr>
<tr>
<td>Involvement</td>
<td>Upper Stream</td>
<td>2.69</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.87</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.18</td>
<td>0</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>Upper Stream</td>
<td>2.00</td>
<td>0.70</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.27</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.27</td>
<td>0.06</td>
</tr>
<tr>
<td>Investigation</td>
<td>Upper Stream</td>
<td>2.93</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>3.14</td>
<td>0.92</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.21</td>
<td>0.01</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Upper Stream</td>
<td>2.10</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.28</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.18</td>
<td>0.04</td>
</tr>
<tr>
<td>Equity</td>
<td>Upper Stream</td>
<td>2.00</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Lower Stream</td>
<td>2.21</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>Difference</td>
<td>0.21</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Upper stream n=265;  Lower stream=215;  Mixed ability=101
This difference between actual and preferred scores on the WIHIC can be called ‘student aspirations’ because it measures the difference between their current perceived classroom environment and their ideal classroom environment. Having established that there was a significant difference between the actual scores and the preferred scores across the whole sample, the same differences were measured after the groups were split for stream. Table 4 separates the data between upper stream and lower stream classes. It can be seen from the data that in every scale the upper stream is seeking greater changes than the lower stream. In the scales of equity, cooperation and teacher support the differences between the actual and preferred environments for the upper and lower stream are very small. For investigation, task orientation, student cohesiveness and involvement, the upper stream show a much greater difference between their actual and preferred classroom learning environments than do the lower stream.

### Table 4
Comparison of the Differences Between the Actual and Preferred Forms of the WIHIC for Each of the Streams

<table>
<thead>
<tr>
<th>WIHIC Scales</th>
<th>Differences between actual and preferred scale mean scores for each stream (aspirations of each group)</th>
<th>Comparison of differences between aspirations of each group.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Upper</td>
<td>Lower</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>0.45</td>
<td>0.36</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>0.52</td>
<td>0.51</td>
</tr>
<tr>
<td>Involvement</td>
<td>0.49</td>
<td>0.40</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>0.56</td>
<td>0.47</td>
</tr>
<tr>
<td>Investigation</td>
<td>0.78</td>
<td>0.63</td>
</tr>
<tr>
<td>Cooperation</td>
<td>0.39</td>
<td>0.38</td>
</tr>
<tr>
<td>Equity</td>
<td>0.47</td>
<td>0.46</td>
</tr>
</tbody>
</table>

* *p<0.05, **p<0.01 Upper stream n=265 Lower stream n=215 Mixed ability n=101

It can therefore be seen that the lower stream had the least aspirations for change in their classroom environment even though they rated their environment the lowest. This is indicative of an attitude of acceptance. It appears that the students feel that this is where they belong and this is what the lower stream is like and “what is the use of trying to climb out of this?” Educators need to assess whether this is what we want for up to half of our students in a year level.

Even though upper stream students rated their learning environment more highly than the lower stream, they were in fact seeking greater change than the lower stream students. It could be said that they ‘cared’ more about their learning.

The situation became a little more concerning when analysis showed that the perceptions Year 9 students have of their learning environment becomes more favourable for upper stream students as they progress into Year 10 while becoming more negative for lower stream students. The research therefore indicates that the gap between the perceived classroom environment in upper and lower streams in Year 9 widens significantly for students as they progress into Year 10. Whatever the perceived damage being done to student perceptions of their learning environments by streaming, the gap widens over time.

To more clearly illustrate the trend of more negative perceptions of classroom environment as the students make the transition from Year 9 to Year 10, Figure 1 (upper stream) and Figure 2 (lower stream) show a widening gap between the perceptions of students in Year 9 and Year 10 for several scales of the WIHIC.

Remembering that lower scores represent more positive outcomes on the version of the WIHIC used for this study, in Figure 1 it can be seen that the upper stream in Year 10 is more positive about their learning environment on most scales of the WIHIC than the upper stream in Year 9. There has been an improvement in the perceptions they have of their learning environment between Year 9 and Year 10.

Figure 2 demonstrates that the trend is in the opposite direction for the lower stream students. The lower stream Year 10 students have a less positive perception of their classroom learning environment on most scales of the WIHIC than do the lower stream Year 9 students.
It is therefore of great concern that while for many significant reasons students in Year 9 lower stream mathematics classes rate their classroom learning environments the way they do, they rate them even lower in Year 10. To contrast this however, upper stream students see an improvement in their learning environment going from Year 9 to Year 10.

Table 5
Compares Scale Means for Upper and Lower Stream Year 9 and Year 10 Students on the Seven Scales of the WIHIC

<table>
<thead>
<tr>
<th>Scale Means</th>
<th>Upper Stream</th>
<th>Lower Stream</th>
<th>Difference</th>
<th>Upper Stream</th>
<th>Lower Stream</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>2.02</td>
<td>1.91</td>
<td>0.11</td>
<td>2.05</td>
<td>2.09</td>
<td>-0.04</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>2.70</td>
<td>2.17</td>
<td>0.53**</td>
<td>2.33</td>
<td>2.95</td>
<td>-0.62**</td>
</tr>
<tr>
<td>Involvement</td>
<td>2.79</td>
<td>2.61</td>
<td>0.18</td>
<td>2.73</td>
<td>2.98</td>
<td>-0.25*</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>1.99</td>
<td>2.01</td>
<td>-0.02</td>
<td>2.04</td>
<td>2.47</td>
<td>-0.43**</td>
</tr>
<tr>
<td>Investigation</td>
<td>2.92</td>
<td>2.93</td>
<td>-0.01</td>
<td>2.94</td>
<td>3.30</td>
<td>-0.36**</td>
</tr>
<tr>
<td>Cooperation</td>
<td>2.12</td>
<td>2.08</td>
<td>0.04</td>
<td>2.26</td>
<td>2.30</td>
<td>-0.04</td>
</tr>
<tr>
<td>Equity</td>
<td>2.25</td>
<td>1.79</td>
<td>0.46**</td>
<td>1.94</td>
<td>2.44</td>
<td>-0.5**</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01

Year 9: Upper n=118  Year 10 :Upper n=147  Year 9 Lower: n=97  Year 10 lower: n=118

The difference in perception is perhaps one of the areas where the comment ‘nothing succeeds like success’ carries some credence (Hirsh, Kett, & Trefil, J. (eds), 2002; Alden, 1987). Students who have success at Year 9 in the upper stream appear to become more positive in Year 10, perhaps thinking about careers requiring mathematics and looking forward to further achievement at a higher level. Unfortunately it appears that the converse is also true that ‘nothing fails like failure’. Lower stream students see lower streams as not having the same motivation or positive behaviour, are not able to stay on task, having less enthusiastic teachers and having a poorer attitude to class. These findings could point to the possibility that as the years go by for a student, failing mathematics as a subject can become a learned response. Utsumi and Mendes (2000) commented on this when they said: “As schooling progresses, attitudes towards mathematics become less positive, a fact that may be associated with the decrease in the understanding of the subject or of the content taught.” p. 241
If it were to happen that schools with traditions of streaming their mathematics classes in Year 9 and 10 decided that they wanted to revert to mixed ability classes, they would no doubt have plenty of resistance from stakeholders. The qualitative data gleaned from this research indicated that streaming in many cases is so much part of our culture, that each interested party tended to accept it as a practice – even students in lower streams.

An example of this is that a lower stream student disliked the streaming because she was afraid of feeling ‘dumb’ when in the presence of the others:

*Ali: I think it would be good to have all the kids doing the same level of maths in the same class so the teacher is working with them all at the same time and can help them all on a closer level. It would also be better because everyone is doing the same work and can work through it together and this way no one has to feel stupid or dumber if they're doing a less challenging maths. (lower stream)*

Trainee teachers were also asked their opinion on the benefits of streaming. The responses were interesting and reflected the fact that these people had come from upper streams themselves and feared being placed as a teacher in lower streams. There is a real risk that stereotyping of streamed mathematics classes is self-perpetuating. An example of a comment from a trainee teacher was:

*Higher stream kids want to ‘give it a go’ while lower stream kids want to ‘muck around’*

Practising teachers also spoke in favour of streaming for various reasons. Some were thinking of their own workload and classroom management while others were thinking about how they would get through the prescribed content. They were all practical issues:

*Teacher 1: We have often wondered about what damage we may be doing with streaming but the parents want it and it is a way we can get the kids ready for Year 11 and 12 where they would stream themselves anyway by choice of subjects.*

*Teacher 2: I just can’t see any other way around it. There is content to cover and this is the most efficient way of doing it.*

Even parents couldn’t see the real issues with streaming – even if their child was in a lower stream:

![Figure 2. Comparing Year 9 and Year 10 lower stream student scores on each scale of the WIHIC. Lower values correspond to more positive perceptions.](image-url)
Students that are brighter can go ahead while the others stay behind. They need the open space to be able to develop at their own speed without being slowed down by other children. The slower children in maths need extra help and care which they can be given at their own speed. It's frustrating for a teacher to do both ends of the scale at once, and tiring. All round it's better for everybody; behaviour in the class would be a great deal better.

CONCLUSIONS

The study of learning environments is a very interesting field and can provide practising teachers with valuable information about the health of their classroom interactions. The research discussed in this paper shows that the quantitative data (information collected by a survey instrument) was validated by the qualitative (information collected by interviews) data. Collecting this information left no doubt in the mind of the researcher that in the large majority of cases academic streaming in mathematics is part of the academic and social fabric of private school life in Australia. Perhaps it is ingrained into students, trainee teachers, teachers and parents. Each of these stakeholders rarely sees the issues involved with streaming, but if they do they accept it as ‘just what happens’.

Apart from the significant findings already discussed, differentiation was also able to be made between the classroom environment perceptions of girls as opposed to boys. It was also valuable to be able to track the connection between the students’ attitude to mathematics as a subject and their perception of their learning environment.

Should schools consider de-streaming their mathematics classes? Certainly this should not happen without plenty of consideration. Should skilled, qualified and motivated teachers be on hand to teach mixed ability classes where peer support for students and parallel programs need to be used in a setting of group work and investigations. It is possible that mixed ability classes could put students in a worse position than streaming if it is not thought out carefully.

How does a school make the best out of a streaming situation? It is about changing the culture of the mathematics department. A good place to start is by putting those teachers recognized as the more motivating practitioners with the lower stream classes.

REFERENCES

THE USE OF MIXED MODE DELIVERY AS AN EFFECTIVE PEDAGOGICAL APPROACH IN ICT-RICH CLASSROOM

Koh Noi Keng
National Institute of Education Singapore
Nanyang Technological University
Singapore

ABSTRACT

The pedagogy that is used with pre-service teachers will somehow affect pre-service teachers’ attitudes towards the subject and their self-efficacy. This paper describes and provides evidence to support this assertion. To teach the net generation in today’s classrooms calls for alternative teaching approaches that are engaging so as to sustain pre-service teachers’ learning. This paper reports the effectiveness of the Mixed Mode Delivery (MMD) teaching approach in ICT-Rich classrooms in Singapore educational context. The effectiveness of the MMD was measured by pre-service teachers’ perceptions towards their learning environment; their attitude towards the subject and self-efficacy using two widely used, validated and reliable questionnaires. Pre-service teachers’ learning interest refers to pre-service teachers’ attitude towards subject. As compared to the traditional teaching approach (TA) which is teacher-centred and didactic, the MMD is proven as an effective teaching approach in terms of providing pre-service teachers with a more positive learning environment. Correlation analysis revealed that all aspects of classroom learning environment provided by the MMD pedagogical framework have positively influenced pre-service teachers’ attitudes toward subject being learnt and their self-efficacy. The paper concludes with remark on the importance of the MMD as alternative innovative instructional approach for a viable model for sustaining interest in a high-tech world.

INTRODUCTION

The demands of the knowledge-based economy, the new profile of learners and the advent of information and communication technology (ICT) have inevitably changed the roles of teachers and students. Significant changes include classroom dynamics, as well as teaching and learning styles. Learning theories of multiple intelligences (Gardner, 1983) and learning styles (Kolb, 1981) help us to understand that there are different preferred learning styles. Teachers have to be adept in employing pedagogical practices that will meet the needs of the net generation (Tapscott, 1997) and prepare them for the future workplace.

This paper reports the evaluation of the effectiveness of using the Mixed Mode Delivery model (MMD) among pre-service teachers in terms of the learning environments of pre-service teachers. The MMD model basically adopts a constructivist approach to teaching and learning. The emphasis is on meaningful learning through a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed and experiential learning opportunities are provided through pedagogically sound activities to enhance learning. In using the MMD, teachers increasingly emphasize authentic learning activities and mix and match strategies and activities according to the profile of learners, the content and skills to be learned. Assignments often are customised for individuals or collaborative groups, and assessment is based on outcomes that could be assessed in terms of both process and product.

This research is the first of its kind where learning environment instruments were employed for evaluating perceptions of learners in a learning environment where an innovative pedagogical framework for learning business subjects was used in an ICT-rich learning environment.

BACKGROUND

This study investigated the impact of using a pedagogical framework that involves a broad array of teaching and learning strategies in an outcomes-focused, technology-rich, constructivist environment called the Mixed Mode Delivery (MMD) framework. It is an original creation by the researcher, who has had 20 years of experience in education and has been using this progressive model with teachers and students. This study did not focus on evaluating a specific tool or a strategy per se, but attempted an understanding of the perceptions of learners in a learning environment that adopts the MMD framework. The MMD, amongst other things, incorporates strategies that harness the ever-changing advances in ICT.

As a pedagogical framework, the MMD applies constructivism in specific learning situations. The literature on the social construction of meaning marks a clear shift in the concern with social interaction, and collaborative
learning in the classroom. Teachers are reconstructing their roles as mediators of students' encounters with their social and physical worlds and as facilitators of students' interpretations and conceptualisations (von Glasersfeld, 1987, 1996). Thus, this social constructivist epistemology is seen to be shaping educational research and curriculum development. Learners learn by making meaning and through processing and reflecting on materials and interacting with them, thereby creating understanding. Constructivists recognise that learning occurs not in a vacuum but is embedded in a particular social setting called the learning environment (Duit & Treagust, 1995).

In order to evaluate the effectiveness of using the MMD, this study capitalised on the extensive field of learning environment which provides a rich array of useful instruments (Fraser, 2002) that have been validated across the world over the past three decades and across the world. It provided an appropriate framework for the evaluation of the effectiveness of MMD with pre-service teachers.

RESEARCH METHODOLOGY

The current research involved evaluating the effectiveness of MMD, a pedagogical framework designed to engage learners in a constructivist learning environment. The sample consisted of 123 pre-service teachers, who took part in both the quantitative as well as the qualitative methods in this study. The research questions are as follows:

1. Is the use of the Mixed Mode Delivery model with pre-service teachers effective in terms of:
   (a) Congruence between actual and preferred learning environments
   (b) Changes over time in pre-service teachers’ attitudes (attitudes to subject, attitudes to computer usage and self-efficacy)
2. Are there associations between perceptions of learning environment and attitudes for pre-service teachers?
3. Is the use of the Mixed Mode Delivery model effective in terms of qualitative information gathered from pre-service teachers about their learning environment?

The intervention requires pre-service teachers to use the constructivist, student-centred approaches which harness ICT ranging from online worksheets, mind maps to virtual field-trips. Before statistical analyses could be undertaken to address the research questions regarding the effectiveness of Mixed Mode Delivery model, the reliability and validity of the instruments used in this research were established. To evaluate the effectiveness of the MMD approach, comparisons were made between the MMD and TA groups in terms of the relative magnitudes of the gap between actual and preferred learning environment. Data collected from 81 MMD pre-service teachers from the MMD experimental group, 42 pre-service teachers from the TA group were analysed in various ways to investigate the reliability and validity of the modified Constructivist Learning Environment Survey (CLES)/ What Is Happening In this Class? (WIHIC) and attitude instruments (Koh & Fraser, 2005) used for this study.

In this study, an attitude and efficacy instrument was administered to both MMD and TA groups of pre-service teachers at the start of the course (pre-test) and again at the end of the course (post-test). The three affective scales administered to teachers are called Attitude to Subject, Attitude to Computer Usage and Self-Efficacy. This study investigated the opinions of pre-service teachers about their experience with the MMD model with respect to constructivist learning environment dimensions.

For qualitative methods, data were gathered through focus-group discussions with all 123 pre-service teachers and reflection logs. By harnessing technology into research methods, it represents an attempt to redefine the traditional parameters of focus-group discussions and engaging in reflective practice against the more contemporary context of the hyper-connected youths where chatting and blogging can take place “anytime, anywhere”. The reflection logs and interviews with six pre-service teachers served to substantiate the findings from quantitative results. In addition, to triangulate findings from the quantitative methods, additional insights from qualitative data collection were sought. Although there was no collection of data directly from students, the pre-service teachers who had taught them during practicum frequently discussed their students’ reactions to a constructivist learning environment by making reference to WIHIC scales such as Task Orientation and Involvement.

Based on the recommendation of Kvale (1996), the size of the sample for the one-on-one interviews was determined once the qualitative data appeared to have reached a saturation point at which subsequent interviews were going to identify similar data. In this study, after the fifth interviewee, it was already quite clear that the range of perspectives was uncovered and the last interview was conducted to ensure that this was so. Teachers were randomly selected from the MMD group, based only on whether they had used the MMD during their practicum in schools.

As recommended by Merriam (1998), in this study, the interviews were semi-structured but open-ended whenever possible. These interviews were recorded as field notes and coded for analysis so as to identify features of each learning environment dimension which might have led to a positive learning environment. The
semi-structured interviews involved asking the respondent a series of questions and then probing, where necessary, to obtain additional information using open-ended questions such as: “What are some examples of these problems?”

Specifically the semi-structured interview comprised a three-step format. Firstly, pre-service teachers were asked to think about the use of MMD in the university and in schools. The interviewer began asking them about MMD in the context of the business studies learning environment that they had experienced first as a learner and then as a teacher assessing the learning environment based on their students’ feedback during their practicum at school. Secondly, pre-service teachers were asked about their retrospective perceptions of the learning environment. In particular, they were asked to explain apparent differences between their current responses (i.e., during the interview) and their past responses to the WIHIC/CLES. To assist with the comparison, each respondent was given the copy of the WIHIC/CLES that they had completed in class several weeks previously. Thirdly, more detailed explanations were sought about students’ perceptions in relation to key issues by focussing them on specific items in the quantitative findings and those of the Focus-Group Discussions and reflection reports.

Rather than using technical procedures involving an explicit category classification system, reflective analysis was used to analyse the data obtained from the pre-service teachers’ interviews (Borg, 2003). Such narratives provided more meaningful information.

DATA ANALYSES AND FINDINGS

To address the research questions, this study capitalised on the strengths of combining two research approaches to provide multiple perspectives for framing the learning environment study and its methods. Quantitative methods involved the administration of learning environment and attitude questionnaires to pre-service teachers while qualitative methods collected data through focus group discussions, reflection and interviews.

Findings from quantitative methods

The difference between the average item mean for actual and preferred scores is shown for each learning environment scale in Table 1 separately for MMD and TA teachers. This actual-preferred difference score is labelled as the ‘gap’ in Table 1. These actual-preferred gaps also are reported in the second last column as ‘effect sizes’, or the difference between actual and preferred scores on a scale expressed in standard deviation units. The effect size for a scale is calculated by dividing the difference between the actual and preferred means by the pooled standard deviation. The effect size provides an indication of the magnitude or educational importance of a difference, as distinct from its statistical significance. Finally, Table 1 reports the statistical significance of actual-preferred differences on each CLES/WIHIC scale for each group of teachers. The statistical significance of the actual-preferred differences for each scale was ascertained by performing a MANOVA for repeated measures, separately for the MMD group and the TA group, for set of learning environment scales as a whole. When Wilks’ lambda criterion revealed statistically significant differences between actual and preferred scores overall for the set of six environment scales, the univariate ANOVA was interpreted separately for each of the six individual CLES/WIHIC scales.
Table 1

<table>
<thead>
<tr>
<th>Scale</th>
<th>Group</th>
<th>Average Item Mean</th>
<th>Gap</th>
<th>Average Item SD</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Act</td>
<td>Pref</td>
<td>A–P</td>
<td>Act Pref</td>
</tr>
<tr>
<td>Personal Relevance &amp; Uncertainty</td>
<td>MMD</td>
<td>3.72</td>
<td>4.20</td>
<td>0.48</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>3.54</td>
<td>4.02</td>
<td>0.48</td>
<td>0.57</td>
</tr>
<tr>
<td>Critical Voice &amp; Shared Control</td>
<td>MMD</td>
<td>3.51</td>
<td>4.21</td>
<td>0.71</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>3.32</td>
<td>3.95</td>
<td>0.63</td>
<td>0.76</td>
</tr>
<tr>
<td>Involvement</td>
<td>MMD</td>
<td>3.52</td>
<td>4.03</td>
<td>0.52</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>3.14</td>
<td>3.69</td>
<td>0.55</td>
<td>0.79</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>MMD</td>
<td>3.96</td>
<td>4.36</td>
<td>0.39</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>TA</td>
<td>3.82</td>
<td>4.31</td>
<td>0.48</td>
<td>0.43</td>
</tr>
<tr>
<td>Investigation</td>
<td>MMD</td>
<td>3.12</td>
<td>3.70</td>
<td>0.61</td>
<td>0.68</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>.93</td>
<td>.81</td>
<td>.87</td>
<td>.77</td>
</tr>
<tr>
<td>Cooperation</td>
<td>MD</td>
<td>.32</td>
<td>.50</td>
<td>.17</td>
<td>.58</td>
</tr>
<tr>
<td></td>
<td>T</td>
<td>4</td>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>.05</td>
<td>.35</td>
<td>.30</td>
<td>.64</td>
</tr>
</tbody>
</table>

***p < 0.001

The sample consisted of 123 pre-service teachers from the experimental MMD (n=82) and comparison TA (n=41) groups. The gap is the difference between the preferred and the actual average item mean. The effect size is the difference between the actual and preferred means divided by the pooled standard deviation.

The statistical significance of the differences between actual and preferred scores on each learning environment scale was explored by conducting a MANOVA for repeated measures separately for the MMD and TA groups. CLES/WIHIC scales constituted the dependent variables and the form of the questionnaire (actual or preferred) was the independent variable. Because the multivariate tests using Wilks’ lambda criterion indicated that statistically differences ($p<0.01$) between actual and preferred scores existed for the set of six learning scales for both MMD and TA teachers, the univariate ANOVA for repeated measures was interpreted for each individual learning environment scale. The F ratio obtained from each ANOVA is provided in the last column of Table 1.

Table 1 shows that the differences between actual and preferred scores were statistically significant ($p<0.001$) for each of the six CLES/WIHIC scales for both the MMD group and the TA group. This finding of a gap between actual and preferred classroom environment is highly consistent with considerable past research (Fraser, 1998).

The effect sizes for the gap between actual and preferred learning environment scores are appreciably larger for the TA group than for the MMD group on the three scales of Task Orientation, Investigation and Cooperation.

According to respondents in the MMD group during the qualitative part of the study, more could have been done to empower pre-service teachers in self-directed learning in a constructivist learning environment and to involve them in participating in curriculum design and pedagogical planning and activities. Having been exposed to the numerous constructivist approaches, they were challenged to participate enthusiastically in lessons, including the design and management of learning activities, through determining and applying assessment criteria and participating in the negotiation of the social norms of the classroom. Therefore, realising that there is still a long way to go in achieving a constructivist learning environment, where learners are empowered and
engaged in self-directed learning, it is not surprising that the preferred rating is higher than the actual rating on many of the CLES/WIHIC scales.

While it was commonly thought that the traditional teacher-centred approach of instructional delivery was more structured, and thereby more task-oriented than the MMD in covering the topics in the syllabus, the findings in this study revealed otherwise. Surprisingly, pre-service teachers in the MMD group perceived their actual learning environment as being closer to their preferred learning environment in terms of Task Orientation than did the TA group.

For further quantitative data analyses and discussions, the differences between MMD and TA teachers in the attitudes and self-efficacy are discussed as follows:

Pre-test and post-test means

Effect sizes

MANCOVA results separately for pre-test and post-test

MANCOVA results with pre-test as covariate

Pre-Test and Post-Test Means

Table 2 shows that the attitude and self-efficacy average item means for pre-service teachers in the MMD group were consistently higher than those from TA group for both the pre-test and the post-test. However, the sizes of the differences between TA and MMD groups in terms of attitudes/efficacy seem to be somewhat larger for the post-test than for the pre-test.

These results for teachers’ attitude/efficacy scales are illustrated in Figure 1, which depicts the average item mean obtained on each scale by each teacher group. This pattern is explored.

Table 2

<table>
<thead>
<tr>
<th>Scale</th>
<th>Time</th>
<th>Average Item Mean</th>
<th>Average Item SD</th>
<th>Difference</th>
<th>ANCOVA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TA</td>
<td>MMD</td>
<td>TA</td>
<td>MMD</td>
</tr>
<tr>
<td>Attitude to Subject</td>
<td>Pre</td>
<td>3.62</td>
<td>3.73</td>
<td>0.69</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.76</td>
<td>4.16</td>
<td>0.76</td>
<td>0.59</td>
</tr>
<tr>
<td>Attitude to Computers</td>
<td>Pre</td>
<td>3.48</td>
<td>3.73</td>
<td>0.85</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.83</td>
<td>4.10</td>
<td>0.73</td>
<td>0.71</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>Pre</td>
<td>3.25</td>
<td>3.48</td>
<td>0.47</td>
<td>0.65</td>
</tr>
<tr>
<td></td>
<td>Post</td>
<td>3.48</td>
<td>3.91</td>
<td>0.53</td>
<td>0.57</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01; *** p < 0.001

The sample consisted of 123 pre-service teachers from the experimental MMD (n=82) and comparison TA (n=41) groups.

Effect sizes

The third last column of Table 2 reports the differences between MMD and TA teachers as effect sizes (i.e. differences in means divided by the pooled standard deviation). The effect sizes in Table 2 indicate that the differences between TA and MMD groups ranged from 0.16 to 0.41 standard deviations for the pre-test. By the time of the post-test, these between-group differences were somewhat larger, ranging from 0.38 to 0.78. The two effect sizes that would be categorised as large according to Cohen’s (1988) criteria are for the post-test administration of the Attitude to Subject scale (0.59 standard deviations) and the Self-Efficacy scale (0.78 standard deviations).

It has been reported that effect sizes in past educational research typically are modest, with average of only 0.40 standard deviation according to Fraser, Walberg, Welch and Hattie’s (1987) synthesis of 134 meta-analyses encompassing 7,827 students. In my study, the effect sizes in Table 2 are comparable to or larger than this average value of 0.40 from past research for Attitude to Subject (post-test only) and Self-Efficacy (both pre-test and post-test). In turn, these effect sizes suggest that most differences between MMD and TA groups have practical significance. These preliminary results tentatively support the effectiveness of using MMD among pre-service teachers in terms of somewhat higher attitude and self-efficacy scores than for TA teachers.
MANOVA results separately for pre-test and post-test

For the set of three attitude scales, a MANOVA was performed separately for attitude/efficacy pre-test and post-test data to ascertain the statistical significance of the differences between TA and MMD groups. Because the results overall were found to be statistically significant using Wilks’ lambda criterion in both cases, the univariate ANOVA results for each attitude/efficacy scale were interpreted. The $F$ values from ANOVA are reported in the second-last column of Table 2.

Differences between TA and MMD in Table 2 are statistically significant ($p<0.05$) in three cases: post-test data for Attitude to Subject: and both pre-test and post-test data for Self-Efficacy. In each of these three cases, the MMD group had higher attitude scores than the TA group.

MANCOVA results with pre-test as covariate

Dugard and Todman (1995) demonstrate that examining the change between pre-test and post-test scores is not necessarily the best way to analyse data. Hence, to reduce error variance and to adjust scores on a covariate (in this case, the pre-test scores), a one-way multivariate analysis of covariance (MANCOVA) was performed for the teacher attitude data.

In this one-way MANCOVA, the independent variable was the teaching practice intervention (MMD or TA) and the dependent variables were post-test scores on the set of three attitudes and self-efficacy scales. Corresponding pre-test scores were used as the covariate. In effect, this analysis provides information about the relative sizes of the pre-post changes experienced by the MMD and TA groups.

Because MANCOVA revealed significant results for the set of attitude and efficacy scales as a whole using Wilks’ lambda criterion, the ANCOVA results for each individual attitude scale were interpreted. The last column of Table 2 shows the ANCOVA results for the Attitude to Subject, Attitude towards Computer Usage and Self-efficacy.

Using pre-test scores as a covariate, there were significant differences between the MMD and the TA groups in terms of post-test scores for Attitude to Subject ($F(1,120)=12.57$, $p<0.001$) and Self-efficacy ($F(1,120)=12.24$, $p<0.001$). That is, MMD pre-service teachers experienced larger improvements in Attitude to Subject and Self-efficacy than those in the TA group. For Attitude to Computer Usage, however, no significant difference was found between MMD and TA groups when the pre-test scores were used as the covariate. This possibly could be explained by the fact that, for both TA and MMD learning environments, ICT is harnessed in the teaching and learning of the subject. The educational landscape of Singapore education scene is such that all schools harness IT in the class and therefore, being IT savvy, our pre-service teachers in both groups are equally

---

**Figure 1.** Comparison of Pre-test and post-test attitude and efficacy scores of MMD and TA teachers.

**Attitude Scales**

<table>
<thead>
<tr>
<th>Attitude to Subject</th>
<th>Attitude towards Computer Usage</th>
<th>Self-Efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre Post Pre Post Pre Post</td>
<td>Pre Post Pre Post Pre Post</td>
<td>Pre Post Pre Post Pre Post</td>
</tr>
<tr>
<td>TA</td>
<td>MMD</td>
<td>TA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average Item Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
</tr>
</tbody>
</table>

$F(1,120)=12.57$, $p<0.001$ for Attitude to Subject.

$F(1,120)=12.24$, $p<0.001$ for Self-efficacy.

$F(1,120)=12.24$, $p<0.001$ for Attitude to Computer Usage.
comfortable using the computer, thus, showing no significant difference in the pre-post increase in their Attitude to Computer Usage. Overall the MANCOVA results provide positive support for the efficacy of the MMD in terms of teachers’ attitudes and efficacy. Overall the results suggest that the two instructional groups differ in their relative effectiveness in terms of pre-service teachers’ Attitude to Subject and Self-efficacy. This provides further evidence to support the efficacy of the MMD as a more effective pedagogical framework in terms of building more positive Attitude to Subject and Self-efficacy but not Attitude to Computer Usage, when pre-test scores are statistically controlled.

Associations between learning environment perceptions and attitudes

This study also investigates the associations between pre-service teachers’ attitude scales namely, Attitude to Subject, Attitude towards Computer Usage and Self-efficacy, and their scores on each of the six CLES/WIHIC learning environment scales, which is Research Question 2. To address this research question, simple correlations analysis was used to indicate the bivariate association between each attitude scale and each learning environment scale. Multiple regression analysis was used to explore the combined influence of the set of learning environment scales on each attitude scale. The standardised regression coefficient was used to indicate whether a particular learning environment scale was related to attitudes when the rest of the learning environment scales were mutually controlled.

Associations between pre-service teachers’ learning environment perceptions and attitudes

Attitude-environment associations are reported in Table 3 for the sample of 123 pre-service teachers. The attitude scales were Attitude to Subject, Attitude to Computer Usage and Self-efficacy, and pre-service teachers’ perceptions of their university classroom environments were assessed with the six CLES/WIHIC scales. Table 3 reports the simple correlation \( r \) between each attitude/efficacy scale and each learning environment scale. The multiple correlation \( R \), at the bottom of Table 3, provides a measure of the joint influence of all six learning environment scales on each attitude scale. The standardised regression coefficients \( \beta \) show the unique contribution of each learning environment scale to each attitude and efficacy scale. The multiple regression analyses reduce the Type I error rate associated with the simple correlation analysis.

Table 3 shows that the simple correlation between an attitude scale and a learning environment scale was statistically significant \( p<0.01 \) for all six CLES/WIHIC scales for both Attitude towards Subject and Self-efficacy, and for all CLES/WIHIC scales except Critical Voice/Shared Control for Attitude to Computer Usage.

Table 3
Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers’ Attitude/Efficacy and CLES/WIHIC Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Attitude-Environment Association</th>
<th>Attitude to Subject</th>
<th>Attitude to Computers</th>
<th>Self-efficacy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>( r )</td>
<td>( B )</td>
<td>( R )</td>
</tr>
<tr>
<td>Personal Relevance and Uncertainty</td>
<td>0.44**</td>
<td>0.15</td>
<td>0.20*</td>
<td>0.05</td>
</tr>
<tr>
<td>Critical Voice and Shared Control</td>
<td>0.44**</td>
<td>0.21</td>
<td>0.13 -0.12</td>
<td>0.39**</td>
</tr>
<tr>
<td>Involvement</td>
<td>0.34**</td>
<td>-0.09</td>
<td>0.18*</td>
<td>-0.03</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>0.46**</td>
<td>0.18</td>
<td>0.29** 0.27*</td>
<td>0.40**</td>
</tr>
<tr>
<td>Investigation</td>
<td>0.38**</td>
<td>0.17</td>
<td>0.34** 0.30*</td>
<td>0.52**</td>
</tr>
<tr>
<td>Cooperation</td>
<td>0.39**</td>
<td>0.13</td>
<td>0.16*</td>
<td>-0.07</td>
</tr>
<tr>
<td>Multiple Correlation ( R )</td>
<td>0.57**</td>
<td>0.40**</td>
<td>0.58**</td>
<td></td>
</tr>
</tbody>
</table>

\( * \ p < 0.05; ** \ p < 0.01 \)

N=123 pre-service teachers

The multiple correlation \( R \) for the set of CLES/WIHIC scales was statistically significant \( p<0.01 \) for each of the three attitude and efficacy scales as shown in Table 3. This suggests that the learning environment overall is related to the pre-service teachers’ attitudes on each scale. The association between learning environment and attitude variables is moderately strong based on the size of the multiple correlation \( R \) for Attitude to Subject,
Attitude towards Computer Usage and Self-efficacy of 0.57 and 0.40 and 0.58, respectively. Standardised regression coefficients were used to provide information about the unique contribution of each learning environment scale to each attitude and efficacy scale when the other environment scales were mutually controlled. The standardised regression coefficients in Table 5 show Task Orientation and Investigation are significantly and independently related to Attitude to Computers. The Investigation scale is the only statistically significant independent predictor of Self-efficacy when the other five environment scales are mutually controlled.

It is noteworthy in Table 3 that every statistically significant simple correlation and regression coefficient is positive, confirming that a more favourable classroom environment is associated with higher teachers’ attitude and efficacy scores. Overall, the findings of positive attitude-environment associations found in Table 5 replicate considerable prior research (Fraser, 1994, 1998a; Goh & Fraser, 1995; Goh et al., 1995; Khoo & Fraser, in press; Riah, 1998; Wong & Fraser, 1996).

Quantitative findings for pre-service teachers’ learning environment perceptions and attitudes

The use of quantitative methods, have revealed results that are summarised as follows.

- Past research was replicated in that the actual classroom environment fell short of the preferred environment by large and statistically significant amounts for both MMD and TA groups and for pre-service teachers’ learning environment.
- TA pre-service teachers’ actual-preferred gap was noticeably larger than the MMD gap for Task Orientation, Investigation and Cooperation (but similar for Personal Relevance, Critical Voice and Involvement).
- MMD teachers experienced significantly larger pre-test-post-test improvements in attitude than did TA teachers in terms of Attitude to Subject and Self-efficacy, but not Attitude to Computers.
- Past research was replicated in that positive bivariate and multivariate associations were found between attitudes and classroom environment for pre-service teachers.

The quantitative findings in this chapter support the assertion that the MMD is a more effective pedagogical model for pre-service teachers as the congruence between actual and preferred classroom environment is better for MMD group than for the TA group. Also the MMD pre-service teachers achieved more positive changes in Attitude to Subject and Self-efficacy than did the TA pre-service teachers.

The results of the simple correlation and multiple regression analysis also established a positive association between a favourable classroom environment and the attitudes of pre-service teachers.

Findings from qualitative methods

This section provides results based on qualitative data to address Research Question 3 that probes the effectiveness of the MMD in terms of qualitative information gathered from focus group discussions, reflective logs and interviews.

In this study, pre-service teachers participated in focus-group discussions at the end of their practicum through a virtual platform, called Blackboard Discussion Forum. The discussion forum elicited voluntary responses from the MMD and TA pre-service teachers. The discussion was led by an independent moderator and the transcripts were only released to the researcher after the pre-service teachers’ examination marks had been submitted to the Board of Examiners, so as not to unduly influence discussions. The recurring themes that emerged and findings from the reflection logs and focus-group discussions are reported and interpreted in the following sections.

Focus-group discussions

A variety of qualitative methods was used to substantiate the quantitative findings from the pre-service teacher respondents in investigating the ways in which pre-service teachers evaluated the MMD model, first from the perspective of a learner who experienced first-hand the use of the MMD model in their university classes, and then in terms of how their teaching and learning environment had been affected during the practicum in schools.

Focus-group discussion was one of the main methods for gathering useful qualitative information before conducting interviews with pre-service teachers after the practicum. Overall, the pre-service teachers in the MMD group were more positive and adventurous in trying out the MMD approach than pre-service teachers from the TA group, who expressed some reservations about using MMD as a pedagogical approach in the school classrooms. These opinions were consistently reported both in pre-service teachers’ focus-group discussions and in their written reflection logs which they submitted at the end of their practicum. These results support the initial claim that the MMD model is an effective teaching and learning approach.
However, another thread that emerged from the pre-service teachers’ focus-group discussions was that, for some of their students, a learning environment undergoing epistemological transformation was perceived as an unsettling experience. When asked to elaborate on their MMD experience, a minority of pre-service teachers reported that this small group of students gave the feedback that they would still like to have the didactic, teacher-centred approach as the preferred learning environment.

Some emerging findings from the analysis were identified and tabulated in Table 4. Pre-service teachers reported that their students preferred the MMD to traditional didactic teacher-talk. The MMD was deemed fun, interesting and engaging. In contrast, most of them considered that the Traditional Approach dull and dry and unable to sustain students’ interest in the lessons. Hence, most gave their support of the MMD for these upper secondary school students, while some seemed to be doggedly holding out as faithful followers of textbook and workbook regime.

As seen from Table 4, 77.24% of the respondents pointed out that students preferred the MMD. The MMD builds a social constructivist learning environment and students welcomed the opportunities provided for interaction and communication (73.98%) when cooperative learning strategies were used. Through the MMD, students seemed to be more energised and motivated and were more creative in working on their tasks assigned (71.54%).

Table 4
Content Analysis of Pre-service Teachers’ Focus-Group Discussions

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Frequency</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Students’ preferred the teaching and learning practices in MMD</td>
<td>95</td>
<td>77.24%</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Effectiveness of MMD</td>
<td>83</td>
<td>67.48%</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Group interaction &amp; communication in class</td>
<td>91</td>
<td>73.98%</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Creativity through MMD</td>
<td>88</td>
<td>71.54%</td>
<td></td>
</tr>
</tbody>
</table>

This study identified a handful of pre-service teachers who would still use the TA because they were not convinced that the MMD would work in classrooms or who felt incompetent to use it. However, the focus-group discussions revealed that most pre-service teachers applauded the use of MMD as they believed that their students welcomed such an approach. Thus, the claim that, to a certain degree, the MMD is superior when compared to the TA, is supported.

Reflection logs
The data obtained from the MMD pre-service teachers’ reflection logs were examined and re-examined to tease out common threads permeating throughout these journals, identifying the pertinent points. From the pre-service teachers’ reflection logs, there emerged five types of sentiments towards the effectiveness and pragmatic use of MMD in schools. These are summarized in Table 5.
Table 5
Classification of Pre-service Teachers Based on Reflection Logs

<table>
<thead>
<tr>
<th>Description of the Sentiments in Each Category</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advocate MMD, saying MMD is effective, and practise MMD</td>
<td>62</td>
<td>75.61%</td>
</tr>
<tr>
<td>Advocate MMD, saying MMD is effective but will use MMD once in a while</td>
<td>5</td>
<td>6.10%</td>
</tr>
<tr>
<td>Believe in MMD, saying MMD is effective but thinks it is difficult to implement; so will not use it in school</td>
<td>6</td>
<td>7.30%</td>
</tr>
<tr>
<td>Do not advocate MMD because it is time consuming and because of classroom management problem</td>
<td>5</td>
<td>6.10%</td>
</tr>
<tr>
<td>Do not advocate MMD because it's not effective</td>
<td>4</td>
<td>4.88%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>82</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

Table 5 indicates that 82% of MMD pre-service teachers gave positive comments stated that the MMD is effective practice and advocate implementing it often (75.61%) or once in a while (6.10%). A small percentage (7.30%) of the MMD teachers believe that the MMD approach is effective, but think that it is difficult to implement and thus will not use it. Only 10.98% of the MMD pre-service teachers provided negative comments by saying that they would not be using the MMD approach because of classroom management problems (6.10%) and believing that the MMD is not effective (4.88%). Based on these findings, the MMD approach appears to be a promising teaching method for which ICT is harnessed to enhance a constructivist learning environment.

**Interviews**

These data not only serve as triangulation but also, more importantly, support and illuminate the quantitative findings. Generally, issues raised during the focus group discussions with 82 MMD and 41 TA pre-service teachers supported the interviews with the six pre-service teachers, which led to the emergence of the following four themes from pre-service teachers evaluation of the impact of using MMD at university:

a) **Authenticity.** Feedback from MMD pre-service teachers suggested that they were eager to invest more time and effort into designing and building good teaching and learning resources for MMD because they could see the value of this task. The outcome, which was the pooling of these resources, was considered to be useful for them when they begin teaching. These activities were considered to be useful for self-improvement in preparation for the real school environment.

b) **Meaning and relevance.** Pre-service teachers also realised that the just-in-time learning and on-the-job training opportunities, when in the MMD environment, were both useful and necessary. These skills and others like scenario planning and role play were practised in a simulated environment before pre-service teachers went out to schools for their practicum.

c) **Flexibility.** The pre-service teachers had great flexibility in the choice of pedagogical tools and practices. While this was welcomed by most of them, some were not comfortable with the nature of such open-ended tasks and preferred specific instructions and limited parameters.

d) **Enjoyment.** Some pre-service teachers reported that they enjoyed the experiential learning and found them meaningful. They did not mind being assessed using these authentic tasks that were embedded in the MMD model. In fact, they welcomed the MMD as a novel way of engaging students in learning and intend to implement it with their students when they become teachers in schools.

Consistent with overall findings from the reflection logs and focus-group discussions, the majority of the pre-service teachers articulated that they preferred the MMD and so did their students, as they found it more interesting and useful than TA. However, many wrote about their reservations in terms of time, classroom management and expectations that would supersede the urge to carry on using MMD as one succumbs to the realistic demands of competing to do well in tests and examinations. Examination results, as the key performance indicator, have put pressure on teachers to resort to didactic methods in misguided attempts to
accelerate the learning process for students. In practice, it is difficult for teachers to stand back and allow students to be given so much responsibility for shaping their own learning. The role of facilitator in using problem-based learning, case method and web quests, for example, is not easy in that it requires a deep understanding of the characteristics and it required the ability to assist learners in constructing meaning, and the ability to foster mutual understanding within the group.

The MMD was considered effective from most of the pre-service teachers’ point of view, which had been reinforced by their students’ feedback during the practicum. Pre-service teachers found the process of preparing the reflection log (a requirement as part of the implementation of the MMD model) to be a useful means of enhancing their professional expertise as reflective practitioners. They had to engage in an online chat with their group members, comment on their blogs (online journals) and participate in focus-group discussions.

The qualitative results discussed in this chapter confirm the assertion from the quantitative results that MMD is an effective pedagogical model. However, there are ‘prerequisites’ which the respondents seemed to collude to: the teacher has to be skillful in classroom management; constraints like lack of time and availability of resources should not be a major obstacle; and, most importantly, support from the school and policymakers. Such situational factors will contribute to the equation for successful implementation of the MMD.

SUMMARY

The results pointed towards a positive impact associated with using the MMD framework with pre-service teachers at the university level. Using the MMD approach, a smaller discrepancy between actual and preferred learning environment scores was found when compared with the TA control group for the CLES/WIHIC scales of Task Orientation, Investigation and Cooperation (but not Personal Relevance, Critical Voice and Involvement). Multivariate Analysis of Covariance (MANCOVA) showed that post-pre improvements in attitude scores for pre-service teachers in the MMD group were consistently higher than those from TA group for Attitude to Subject and Self-Efficacy, but not for Attitude to Computers.

The results clearly provided evidence for the positive impact of using the MMD model with pre-service teachers even when the pre-test attitude and self-efficacy scores were used as covariates. The quantitative findings support the assertion that, to some degree, MMD is a more effective pedagogical model than the TA in terms of learning environment. These quantitative findings were triangulated with findings from analysis of focus-group discussions and reflection logs, which were further substantiated by interviews. Hence, the qualitative findings confirm all preliminary findings that emerged from quantitative analysis.

The MMD and TA groups of pre-service teachers started off with pre-test attitude scores that were not significantly different for Attitude to Subject. The pre-post increases in pre-service teachers’ attitude scores during the intervention were significantly larger for MMD teachers than TA teachers for Attitude to Subject and Self-efficacy. For Attitude to Computer Usage, however, no significant difference was found between MMD and TA groups in post-test scores when pre-test scores were used as the covariate. Because ICT is harnessed in the teaching and learning for both TA and MMD groups, teachers in both groups are equally comfortable with using the computer.

In conclusion, while the robust quantitative instruments provided rigour, the qualitative results and findings illuminated and substantiated the quantitative findings by providing insight into the context of the learning environments at university and at schools. Overall, the quantitative findings coupled with findings and insights from using qualitative methods supported the assertion that, to some degree, the MMD is a more effective pedagogical model than the TA in terms of the learning environment and attitudes of pre-service teachers and their school students during the practicum.

REFERENCES


IDENTIFYING CULTURALLY SENSITIVE FACTORS OF SCIENCE LEARNING ENVIRONMENTS IN WESTERN AUSTRALIA

Rekha B Koul and Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

The present study examines and investigates students’ perception of their learning environment and its associations with their cultural background and attitude to class. A total of 560 students from years 7 and 8 from a multicultural Western Australian public school responded to the Cultural Learning Environment Questionnaire (CLEQ) and an Attitude Scale. Students’ cultural background was established by ascertaining the language spoken at home and their parents’ country of birth. This study provides further validation data for the already existing CLEQ and indicates changing trends in Western Australian schools with regard to cultural sensitivity. Gender differences in students’ perception of cultural background were also established. Associations were drawn between students’ perceptions of their cultural learning environment and attitude to science. These associations examine whether the students’ cultural background affects their attitude.

INTRODUCTION

Western Australian classrooms are becoming increasingly multicultural and the way in which people communicate and perceive communication is culturally influenced (Giles & Franklyn-Stormes, 1989; Segall, Dasen, Berry, & Poortinga, 1990). Okebukola (1986) argued that the cultural background of the learner could have a greater effect on education than does the course content. Consequently, unless students can relate the application of what is taught to their own cultural backgrounds their learning is likely to be less than effective. Many students come from disparate cultural practices and at times the teaching and learning strategies adopted in science classrooms can be perceived as being in conflict with the natural learning strategies of the learner (Waldrip & Fisher, 1996). Since teachers can use practices that may inadvertently conflict with students’ previous learning patterns, home environment, mores and values, there is an increasing need for teachers to be sensitive to the important cultural milieu into which teaching is placed (Thaman, 1993). Although there are a number of studies related to culture and science education generally described in literature (Atwater, 1993; Cobern, 1996; Evans, 1998; Koul & Fisher, 2006; Maddock, 1981) none have made an attempt to study primary science students’ cultural background and their attitudes to science.

CLASSROOM ENVIRONMENT RESEARCH

A key advance in the thinking that contributed greatly to the study of learning environments was the Lewinian formula proposed by an exile from Nazi Germany, Kurt Lewin (1936). It is a key to the human interaction focus of this study in that it proposed that the environment and the personal characteristics of an individual determined human behaviour. This theory was expressed in the formula that human behaviour (B) is a function of both the personality of the individual (P) and the environment (E).

$$B = f(P, E)$$

This formula was to provide a motivating force for new research strategies (Fraser, 1994; Stern, 1970). Murray (1938) developed a theory to describe an individual’s personal needs and environmental press. He defined needs as those specific, innate and personal requirements of an individual such as personal goals. An individual’s need to achieve these goals or their drive to attain them is also a factor in an individual’s personality. The environmental factors that were beyond an individual’s control that either enhanced or retarded the individual’s achievement of their personal goals and needs were defined as press. Murray used the term alpha press to refer to an external observer’s perceptions of the learning environment and beta press to refer to observations by the constituent members of the environment under observation (Murray, 1938).

Stern, Stein, & Bloom (1956) built on Murray’s discrimination between alpha press and beta press. They suggested that beta press could further be discriminated by the individual view and experience of the environment that each student, for example, has of the learning environment versus the shared view that the students have as a group of participants in the learning environment. They used private beta press to represent the idiosyncratic view a student may have of the classroom environment and consensual beta press for the shared view of the students’ perceptions. This study utilises the student consensual beta press perspective for the
data collected through survey and observation methods and private beta press perspective for the interviews conducted with the students.

Classroom research methods about three decades ago were centred on observation techniques where trained observers would categorise classroom activities and interactions between members of the class. Along with an improvement in observation procedures and techniques (Brophy & Good, 1986) came a categorisation of observations as either high or low inference measures which were defined as the specific items that were recorded during classroom observations sessions. High-inference measures recorded during classroom observations required the observer to make an inference about the teacher’s behaviour in terms of such aspects as warmth, clarity or overall effectiveness. Either a member of the classroom environment or an outside observer could make high-inference observations.

Murray’s needs-press model was utilised and extended (Pace & Stern, 1958) to report on high inference measures in educational learning environments. A problem with outside observers is that they must make judgements on the observations that are based on experiences external to the learning environment. Further to this, Pace and Stern (1958) suggested that an assessment of the relationships between the environmental press and a student’s needs might be useful in predicting personal achievement.

CULTURAL LEARNING ENVIRONMENT QUESTIONNAIRE (CLEQ)

The Cultural Learning Environment Questionnaire (CLEQ) was developed by Waldrip and Fisher (1996) to assess the culturally-sensitive factors of the classroom learning environment. The research on dimensions of culture (Hofstede, 1984) and Moos’ dimensions served as the main guide in the development of CLEQ. The other main criteria adhered to when developing the CLEQ were: consistency with previous learning environment research and literature, salience for teachers and students in target audience and economy of operational requirements. The questionnaire has eight scales with five items in each scale giving a total of 40 items. Waldrip and Fisher (1996) used it with the individual student as the unit of analysis and its factor analyses resulted in retaining all the 40 items in eight scales. This study used the CLEQ in primary science classes for one of the first time to measure students’ perceptions on the basis of their cultural backgrounds.

Table 1 illustrates the nature of the CLEQ by providing a sample item for each of the eight scales. Student responses were taken on a four point Likert scale ranging from Almost Always (4) to Almost Never (1).

<table>
<thead>
<tr>
<th>Scale</th>
<th>Sample Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>I feel that female teachers should be shown the same amount of respect as male teachers.</td>
</tr>
<tr>
<td>Collaboration</td>
<td>I would rather decide what to do as a group than to make decision by myself</td>
</tr>
<tr>
<td>Deference</td>
<td>I try to say what the class thinks rather than give my own opinion</td>
</tr>
<tr>
<td>Competition</td>
<td>I worry if I don’t perform as well as other students.</td>
</tr>
<tr>
<td>Teacher Authority</td>
<td>I feel that I can challenge or question what teachers say.</td>
</tr>
<tr>
<td>Modeling</td>
<td>I like to watch how my classmates tackle a problem before I start.</td>
</tr>
<tr>
<td>Congruence</td>
<td>What I learn in this class agrees with what I learn at home.</td>
</tr>
<tr>
<td>Communication</td>
<td>I like to be able to see as well as hear what is happening in class.</td>
</tr>
</tbody>
</table>

STUDENT ATTITUDES TOWARDS SCIENCE

Because of the national importance given to the teaching of science and inculcation of positive attitudes towards science in students, it is both timely and opportune to examine associations between students’ perceptions of cultural factors that affect the learning environment and their attitude towards science. Attitudes towards science were assessed in this study using an Attitude Scale based on the Test of Science Related Attitudes (Fraser, 1981).
METHOD

The overall aim of the study was to investigate associations between students’ cultural backgrounds and their attitude to science. This led to the following objectives which were:

- to further validate the Cultural Learning Environment Questionnaire (CLEQ) instrument for use in multicultural primary science classrooms;
- to investigate whether there were differences in students’ perceptions on the basis of their cultural background;
- to determine whether there were associations between students’ perceptions of their cultural background and attitude to science; and
- to inform teachers about the perceptual differences due to the culture of the students as this can be used as a guide to improve teaching, thereby leading to improved learning.

The research involved administering the CLEQ and the Attitude Scale to a total of 560 students in 20 primary science classrooms (years 7 and 8) in Perth metropolitan schools. Care was taken to include a school where students came from a wide range of cultural backgrounds which was established by including a question ‘Language spoken at home’. Students in this study spoke 45 different languages at home. These 45 languages were grouped into six sets keeping in mind the cultural practices and geographical locations as shown in Table 2.

Table 2
Description of the Groups Created on the Basis of Language Spoken at Home and Number and Percentage of Sample from Each Group

<table>
<thead>
<tr>
<th>Group</th>
<th>Language Spoken at home</th>
<th>N</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>English</td>
<td>446</td>
<td>79%</td>
</tr>
<tr>
<td>2</td>
<td>Vietnamese</td>
<td>43</td>
<td>7.6%</td>
</tr>
<tr>
<td>3</td>
<td>Mandarin, Cantonese, Chinese, Hokkien &amp; Thai</td>
<td>11</td>
<td>1.96%</td>
</tr>
<tr>
<td>4</td>
<td>Arabic, Bosnian, Kurdish, Malay, Persian, Indonesian, Urdu, Croatians, Serbian, Dari</td>
<td>24</td>
<td>4.28%</td>
</tr>
<tr>
<td>5</td>
<td>African, Burmese, Maori, Tagalog, Punjabi, Tamil, Amharic</td>
<td>11</td>
<td>1.96%</td>
</tr>
<tr>
<td>6</td>
<td>Macedonia, Polish, German, French, Italian, Spanish, Hungarian, Romanian, Russian, Yugoslavian</td>
<td>25</td>
<td>4.46%</td>
</tr>
</tbody>
</table>

The validity of the instrument was further confirmed in terms of reliability and ability to differentiate between perceptions of students in different classes and students coming from different cultural backgrounds.

RESULTS

Table 3
Scale Mean, Standard Deviation, Internal Consistency (Cronbach Alpha Reliability) and Ability to Differentiate Between Classrooms (ANOVA Results) for the CLEQ

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Alpha Reliability</th>
<th>ANOVA (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>3.47</td>
<td>.51</td>
<td>.71</td>
<td>.08*</td>
</tr>
<tr>
<td>Collaboration</td>
<td>3.36</td>
<td>.5</td>
<td>.67</td>
<td>.05*</td>
</tr>
<tr>
<td>Deference</td>
<td>2.78</td>
<td>.61</td>
<td>.66</td>
<td>.14*</td>
</tr>
<tr>
<td>Competition</td>
<td>2.26</td>
<td>.73</td>
<td>.77</td>
<td>.04</td>
</tr>
<tr>
<td>Teacher Authority</td>
<td>2.27</td>
<td>.66</td>
<td>.65</td>
<td>.07*</td>
</tr>
<tr>
<td>Modeling</td>
<td>2.55</td>
<td>.65</td>
<td>.69</td>
<td>.04</td>
</tr>
<tr>
<td>Congruence</td>
<td>2.89</td>
<td>.67</td>
<td>.81</td>
<td>.09*</td>
</tr>
<tr>
<td>Communication</td>
<td>2.92</td>
<td>.62</td>
<td>.76</td>
<td>.06*</td>
</tr>
</tbody>
</table>

n= 560 students in 23 classes  
*p<0.01

Table 3 presents the means and standard deviations for each of the scales of the CLEQ indicating that the students perceive a high degree of equity and collaboration in their classroom environments. The deference, competition, authority, modelling, congruence and communication aspects are less noticeable. However, all the
scales have a high mean, the lowest being 2.26 on a four point Likert scale for the scale of Competition. The students perceived equity most favourably with a score of 3.47. The standard deviation for all the scales ranged from 0.5 to 0.73, suggesting that there was not a large diversity in the students’ perceptions.

The validity and reliability information for the CLEQ when used with this primary school Australian sample are also presented in Table 2. To determine the degree to which items in the same scale measure the same aspect of culture, a measure of internal consistency, the Cronbach alpha reliability coefficient (Cronbach, 1951), was used. The highest alpha reliability was obtained for the scale of Congruence and the lowest for Teacher Authority. The reliability results for the scales of the CLEQ were consistently above 0.50 suggesting that it can be considered a reliable tool (De Vellis, 1991) with primary school Australian students.

The ability of a learning environment questionnaire to differentiate between classes is important. The CLEQ’s ability to differentiate in this way was measured using one-way analysis of variance (ANOVA). The \( \eta^2 \) statistic was calculated to provide an estimate of the strength of the association between class membership and the dependent variables as shown in Table 2. The \( \eta^2 \) statistic for the CLEQ, indicates that the amount of variance in scores accounted for by class membership ranged from 0.14 to 0.04 and was statistically significant \( (p<0.01) \) for the scales of Equity, Collaboration, Deference, Teacher Authority, Congruence and Communication. It appears that most of the scales of the CLEQ are able to differentiate clearly between the perceptions of students in different classrooms.

Gender differences

The associations between the students’ perceptions of cultural aspects and the gender of the students were analysed. The gender differences in students’ perceptions of classroom learning environment were examined by splitting the total number into male (294) and female (256) students involved in the study.

To examine the gender differences in students’ perceptions of culture aspects of the science classes, the within-class gender subgroup mean was chosen as the unit of analysis which aims to eliminate the effect of class differences due to males and females being unevenly distributed in the sample. In the data analysis, male and female students’ mean scores for each class were computed, and the significance of gender differences in students’ perceptions of science classroom culture were analysed using an independent t-test. Table 4 shows the scale item means, male and female differences, standard deviations, and t-values. The purpose of this analysis was to establish whether there are significant differences in perceptions of students according to their gender.

As can be seen in the Table 4, out of eight scales of the CLEQ, the gender differences in the perceptions of males and females were found to be statistically significantly different on only two scales. According to the results, female students perceived more positively the equity and communication displayed by their teachers.

Table 4
Item Mean and Standard Deviation for Gender Differences in Students’ Perceptions as Measured by the CLEQ.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Gender</th>
<th>Item Mean</th>
<th>Mean Difference (F-M)</th>
<th>Std. Deviation</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>Females</td>
<td>3.52</td>
<td>.08</td>
<td>.45</td>
<td>7.22*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>3.44</td>
<td></td>
<td>.53</td>
<td></td>
</tr>
<tr>
<td>Collaboration</td>
<td>Females</td>
<td>3.38</td>
<td>.04</td>
<td>.47</td>
<td>2.25</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>3.34</td>
<td></td>
<td>.52</td>
<td></td>
</tr>
<tr>
<td>Deference</td>
<td>Females</td>
<td>2.73</td>
<td>-.08</td>
<td>.62</td>
<td>.88</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.81</td>
<td></td>
<td>.59</td>
<td></td>
</tr>
<tr>
<td>Competition</td>
<td>Females</td>
<td>2.27</td>
<td>.02</td>
<td>.71</td>
<td>.99</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.25</td>
<td></td>
<td>.75</td>
<td></td>
</tr>
<tr>
<td>Teacher Authority</td>
<td>Females</td>
<td>2.16</td>
<td>-.21</td>
<td>.64</td>
<td>.29</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.37</td>
<td></td>
<td>.65</td>
<td></td>
</tr>
<tr>
<td>Modeling</td>
<td>Females</td>
<td>2.47</td>
<td>-.13</td>
<td>.64</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.6</td>
<td></td>
<td>.65</td>
<td></td>
</tr>
<tr>
<td>Congruence</td>
<td>Females</td>
<td>2.88</td>
<td>0</td>
<td>.63</td>
<td>3.67*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.88</td>
<td></td>
<td>.7</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Females</td>
<td>3.01</td>
<td>.17</td>
<td>.59</td>
<td>.5</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.84</td>
<td></td>
<td>.63</td>
<td></td>
</tr>
<tr>
<td>Attitude to Class</td>
<td>Females</td>
<td>2.39</td>
<td>.05</td>
<td>.41</td>
<td>.96</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.34</td>
<td></td>
<td>.43</td>
<td></td>
</tr>
</tbody>
</table>

* \( p=0.01 \) females \((n=256)\); males \((n=294)\)
Cultural differences

Associations between scales of the CLEQ and students, on the basis of the cultural group they come from, were examined. The cultural group of the students was determined by the question ‘language spoken at home’. To examine the cultural differences in the science classes, the within-class cultural subgroup mean was chosen as the unit of analysis which aims to eliminate the effect of class differences due to the strength of various groups being unequally distributed in the sample. In the data analysis, mean scores for each of the six cultural groups were computed. Table 5 shows the scale item means and F values of the scales of the CLEQ with the perceptions of students from the six cultural groups created. The purpose of this analysis is to establish whether there are significant differences in the perceptions of students according to their cultural backgrounds.

As can be seen in Table 5, the differences in the perceptions of students about their science teachers on only two scales out of the eight CLEQ scales are statistically significant. The scales in which there were significant differences were Deference and Competition where the students from Group IV had a higher score. Further analyses will be done on these preliminary measures.

Table 5
Item Mean for Cultural Differences (Language Spoken at Home) in Students’ Perceptions of CLEQ Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Group I Mean</th>
<th>Group II Mean</th>
<th>Group III Mean</th>
<th>Group IV Mean</th>
<th>Group V Mean</th>
<th>Group VI Mean</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>3.5</td>
<td>3.38</td>
<td>3.57</td>
<td>3.46</td>
<td>3.13</td>
<td>3.43</td>
<td>1.39</td>
</tr>
<tr>
<td>Collaboration</td>
<td>3.37</td>
<td>3.4</td>
<td>3.25</td>
<td>3.43</td>
<td>3.26</td>
<td>3.21</td>
<td>.86</td>
</tr>
<tr>
<td>Deference</td>
<td>2.74</td>
<td>2.89</td>
<td>2.58</td>
<td>3.11</td>
<td>2.77</td>
<td>2.88</td>
<td>2.52*</td>
</tr>
<tr>
<td>Competition</td>
<td>2.19</td>
<td>2.54</td>
<td>2.14</td>
<td>2.7</td>
<td>2.62</td>
<td>2.58</td>
<td>5.55*</td>
</tr>
<tr>
<td>Teacher Authority</td>
<td>2.27</td>
<td>2.28</td>
<td>1.97</td>
<td>2.37</td>
<td>2.4</td>
<td>2.33</td>
<td>.81</td>
</tr>
<tr>
<td>Modeling</td>
<td>2.55</td>
<td>2.65</td>
<td>2.28</td>
<td>2.39</td>
<td>2.48</td>
<td>2.65</td>
<td>1.05</td>
</tr>
<tr>
<td>Congruence</td>
<td>2.87</td>
<td>3.05</td>
<td>3.28</td>
<td>2.76</td>
<td>3.06</td>
<td>2.73</td>
<td>2.04</td>
</tr>
<tr>
<td>Communication</td>
<td>2.93</td>
<td>3</td>
<td>3.04</td>
<td>2.83</td>
<td>2.91</td>
<td>2.8</td>
<td>.54</td>
</tr>
<tr>
<td>Attitude to Class</td>
<td>2.36</td>
<td>2.46</td>
<td>2.34</td>
<td>2.34</td>
<td>2.69</td>
<td>2.32</td>
<td>.158</td>
</tr>
<tr>
<td>n=437</td>
<td>n=40</td>
<td>n=14</td>
<td>n=26</td>
<td>n=9</td>
<td>n=25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p<0.01  Total n = 551

Associations between attitude towards science class and the scales of CLEQ

One of the aims of the study was to investigate whether the students’ cultural background affects his/her attitude towards science classes. Associations between the perceptions of the scales of CLEQ and students’ attitudes were explored using simple and multiple correlation analyses. The results of the analyses are shown in Table 6. For all the scales of CLEQ except Equity associations are positive and statistically significant.

The multiple correlation (R) between the set of CLEQ scales and attitude to science class was 0.39. The $R^2$ value which indicates the proportion of variance in attitude to science class that can be attributed to students’ perceptions of the cultural environment was 16%. To determine which of the CLEQ scales contributed most to this association, the standardized regression coefficient (beta) was examined for each scale. It was found that only the scales of Collaboration, Competition, Modeling and Communication retained their significance and were positively and significantly associated with attitude to science classes.
Table 6
Associations between CLEQ Scales and Attitude to Science Class in terms of Simple Correlations (R), Multiple Correlations and Standardized Regression Coefficient ( Beta)

<table>
<thead>
<tr>
<th>Scale</th>
<th>R</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equity</td>
<td>0.01</td>
<td>-0.07</td>
</tr>
<tr>
<td>Collaboration</td>
<td>0.16**</td>
<td>0.09*</td>
</tr>
<tr>
<td>Deference</td>
<td>0.12**</td>
<td>-0.06</td>
</tr>
<tr>
<td>Competition</td>
<td>0.25**</td>
<td>0.17*</td>
</tr>
<tr>
<td>Teacher Authority</td>
<td>0.12**</td>
<td>0.06</td>
</tr>
<tr>
<td>Modeling</td>
<td>0.28**</td>
<td>0.19*</td>
</tr>
<tr>
<td>Congruence</td>
<td>0.17**</td>
<td>0.06</td>
</tr>
<tr>
<td>Communication</td>
<td>0.23**</td>
<td>0.14*</td>
</tr>
</tbody>
</table>

Multiple Correlation
R = 0.39**  R² = 0.16  
n=551  
*p<0.05, **p<0.01

CONCLUSIONS

The results of this study provide further evidence that the CLEQ is a valid instrument for use with Australian students in middle school. Students generally have very positive perception of cultural aspects of their learning environment. This finding does not contradict with earlier studies conducted by Evans (1998) and Waldrip & Fisher (1996).

In this study, there is little statistically significant evidence of differences in students’ perceptions of their learning environment based on their cultural background. This finding is contrary to other research studies in this field. Although data were collected from a multicultural school, significant number of respondents belonged to one group. It is probable that teachers in this selected school are culturally sensitive or students have been living in Australia for a long time and accept an Australian way of life. These factors could have impacted the results obtained in this study. However, further qualitative study is needed to provide more insight into the research questions under investigation.

This study is significant, as it identified the students’ perceptions of cultural factors that affect their classroom-learning environment. Thus, it accepts that students should be active participants in learning process. It further investigates links between students’ perceptions of cultural factors and their attitudes towards science, which affects student outcomes. Through this research study increased understanding of effective teaching of science in primary schools was gained, which can benefit the community through the application of research results to school and education system.

REFERENCES


323


LEARNING ENVIRONMENTS AND ENVIRONMENTAL EDUCATION INSTRUMENT

Rekha B Koul
Curtin University of Technology
Australia
David Zandvliet
Simon Fraser University
Canada

ABSTRACT

Learning environment studies acknowledge that learning takes place within the social realm and social conditions contribute to the quality of learning and experiences. To access the students’ perceptions of their environment, a desire to develop a robust, valid and reliable instrument for Environmental Education (EE) for use by teachers, researchers and evaluators was felt. Focus groups with environmental educators were formed to investigate the factors viewed most important to their pedagogy and likely to influence the unique learning environments fostered in the EE programs. Analysis of this qualitative work resulted in eight scales for inclusion in the questionnaire that was developed or adapted from a variety of previous learning environment questionnaires. The Place-Based Learning and Constructivist Environment Survey (PLACES) was developed. The development and validation of this environmental education inventory are discussed in this paper.

INTRODUCTION

The goal of the United Nations Decade of Education for Sustainable Development (Woods, 7 July, 2005) for which United Nations Education, Scientific and Cultural Organisation (UNESCO) is the lead agency, is to integrate the principles, values, and practices of sustainable development into all aspects of education and learning. This educational effort should encourage changes in behaviour that will create a more sustainable future in terms of environmental integrity, economic viability, and a just society for present and future generations (UNESCO, 2007).

The Australian Government is committed to build on the existing developmental approaches and further embed sustainability education by showing leadership at national level, build capacity, and effect change in individual initiatives that will act as catalyst for wider national change. A number of programs; namely; Green Vouchers for School Program, Educating for a Sustainable Future- A National Environmental Education Statement for Australian Schools and Australian Sustainable Schools Initiative have been formerly administered.

Keeping the current focus in view, a learning environment instrument was developed in North America (Zandvliet, 2007) and further validated in Australia, India and Mauritius.

CONTEXT

It is claimed that many benefits can be achieved by engaging students in environmental education, these include improvement in academic achievement, problem solving, critical thinking, co-operative learning skills, and an increased motivation to learn (Zandvliet, 2007). These accomplishments can help to develop future citizens, who could participate effectively in generating sustainable solutions to the environmental, social and economic issues.

After participating in environmental education programs, students develop a genuine appreciation for the environment (Basile, 2000; Corral-Verdugo & Frais-Armenta, 1996; Cummins & Snively, 2000; Kenney, Price-Militana, & Horrocks-Donohue, 2003; Lieberman & Hoody, 2000; Lord, 1999) Environmental education also promotes and motivates children to engage at all levels of ability (Basile, 2000; Cummins & Snively, 2000; Kenney, Price-Militana, & Horrocks-Donohue, 2003; Lord, 1999) which is attributed to a concrete experience of real issues that come to be perceived as personally meaningful. Students formerly struggling in schools became more interested in schools when environmental education was introduced in the school curriculum (NEETF, 2000). Students’ perception of empowerment leading to a responsibility of making a change in the school environment resulted in a positive behaviour and higher academic achievement across the curriculum (NEETF, 2005).

Constructivist approach to teaching develops deeper comprehensive thought and critical thinking skills in students (Corral-Verdugo & Frais-Armenta, 1996; Lord, 1999). These students also improve their ability at recalling information many months after the completion of a unit.

Environmental education programming also benefits students’ collaborative skills. Students engage in problem solving as a group, engage in meaningful interactions with others that facilitate co-operative learning. Small group and classroom discussions allow children to learn from one another (Zandvliet, 2007). They provide
opportunities for students to share thoughts and knowledge with one another and these discussions help to either reform or confirm students’ beliefs. Environmental education lessons also provide ample opportunities for children to co-operate and work together (Cummins & Snively, 2000; Kenney, Price-Militana, & Horrocks-Donohue, 2003). Lower achieving and average students share learning more often and show greater leadership characteristics as compared to traditional environments.

Environmental education students are often found to develop a greater motivation to learn and potentially deeper understanding and more positive views towards caring for the environment (Ballantyne & Packer, 1996; Bogner, 1998; Cummins & Snively, 2000; Kenney, Price-Militana, & Horrocks-Donohue, 2003). These studies further note that students who experience ‘real-life’ issues develop a perception they can bring about change in environmentally responsible behaviours. The continued longevity of these behaviours is highly dependent on the duration of the environmental education programs.

Through environmental education learners’ cognitive structures altered, attitudes modified and the general learning environment which develops around these programs enriches and stimulates further learning. These elements are viewed as interconnected and will change as a whole system, not as separate parts (Johanson & Johnson, 2003). This research was hence consistent and congruent with environmental views of education. A research study was conducted to examine the types of learning environments developed in environmental education settings in three different countries, namely, Australia, India and Mauritius.

LEARNING ENVIRONMENT RESEARCH

A key advance in the thinking that has contributed greatly to the study of learning environments was the Lewinian formula proposed by Kurt Lewin (1936). As a key to the human interaction focus, this study proposed that the environment and the personal characteristics of an individual determined human behaviour. This theory indicated that human behaviour (B) is a function of both the personality of the individual (P) and the environment (E) and can be expressed as B=f(P, E).

Murray (1938) developed a theory to describe an individual’s personal needs and environmental press. He defined needs as that are specific, innate and personal requirements of an individual, such as personal goals. An individual’s need to achieve these goals, or their drive to attain them, is also a factor in an individual’s personality. The environmental factors that were beyond an individual’s control that either enhanced or retarded the individual’s achievement of their personal goals and needs, were defined as press. Murray used the term alpha press to refer to an external observer’s perceptions of the learning environment and beta press to refer to observations by the constituent members of the environment under observation (Murray, 1938).

Stern, Stein, and Bloom, (1956) built on Murray’s discrimination between alpha press and beta press. They suggested that beta press could be discriminated by the individual view and experience of the environment that each student, has of the learning environment versus the shared view that the students have as a group of participants in the learning environment. They used private beta press to represent the idiosyncratic view a student may have of the classroom environment and consensual beta press for the shared view of the students’ perceptions. This study utilises the student consensual beta press perspective for the data collected through survey and observation methods and private beta press perspective for the interviews conducted with the students.

Considerable progress has been made over the last four decades in the conceptualisation, assessment and investigation of the important, but subtle, concept of learning environments (Fraser, 1986, 1994, 1988a, 1998b; Fraser & Walberg, 1991; McRobbie & Ellett, 1997; Wubbels & Levy, 1993). Research in the past two decades has also employed the use of qualitative methods in learning environment research (Anstine Templeton & Nyberg, 1997; Tobin, Kahle & Fraser, 1990), and also the combination of both qualitative and quantitative methods (Aldridge, Fraser, & Huang, 1999; Anstine Templeton & Johnson, 1998; Fraser & Tobin, 1991; Johnson & Anstine Templeton, 1999; Kou & Fisher, 2004, 2006; Tobin & Fraser, 1998). Studies have reported that students’ perceptions of the classroom environment consistently account for considerable variance in student outcomes (Fraser & Fisher, 1982a, 1982b; Wong & Fraser, 1994).

Until now learning environment studies have mostly concentrated on the science education, however they are applicable to inter/multi-disciplinary field of study, such as environmental education within the science education framework.

DEVELOPMENT OF PLACES

The Place-Based and Constructivist Environment Survey (PLACES) was created in two stages (Zandvliet, 2007). In the first stage, a pilot study was conducted by adapting scales from four different established learning environment inventories: the Environment Science Learning Inventory” (ESLEI) (Henderson & Reid, 2000), the What is Happening in this Class (WHIC), the Science Learning Environment Inventory (SLEI) and the Science Outdoor Learning Environment Instrument (SOLEI) (Orion, Hofstein, Pinchas, & Giddings, 1994). In all, a total
of seven scales from these instruments were used. The scales of Student Cohesion, Integration and Involvement were taken from the ESLEI (Henderson & Reid, 2000). The scales of Teacher Support and Cooperation were taken from WIHIC questionnaire. The scale of Open-Endedness was taken from the SLEI and the final scale of Environmental Interaction was taken from the SOLEI. Both the SLEI and the WIHIC have been used and validated in several large research studies (Fraser, 1998).

In a pilot study, this instrument was trialed in classroom and field based environmental education settings. Students were asked to give their actual and preferred perceptions. Further reflecting on the process of tool creation and validity, and reliability problems encountered with the cursory instrument, a decision was undertaken to create a more robust instrument for use in place-based environmental education settings (Zandvliet, 2007). During the PLACES development, a participatory approach in the evaluation of the learning environment literature and various published instruments was employed. A series of focus groups, conducted over a period of four months resulted in a consensus around eight constructs which were deemed most important to place-based and environmental educators. Table 1 illustrates the nature of the PLACES by providing a scale description and a sample item for each of the eight scales. Student responses were taken on a four point Likert scale ranging from Almost Always (4) to Almost Never (1).

### Table 1

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance/Integration [R/I]</td>
<td>Extent to which lessons are relevant and integrated with environment and field based activities.</td>
<td>Lessons are supported with field experiences and other field-based activities.</td>
</tr>
<tr>
<td>Critical Voice [CV]</td>
<td>Extent to which students have a voice in class.</td>
<td>It’s all right for me to openly express my opinion.</td>
</tr>
<tr>
<td>Student Negotiation [SN]</td>
<td>Extent to which students can negotiate activities in their class.</td>
<td>Other students ask me to explain my ideas.</td>
</tr>
<tr>
<td>Group Cohesiveness [GC]</td>
<td>Extent to which the students know, help and are supportive of one another.</td>
<td>Members of this class help one another during classroom activities.</td>
</tr>
<tr>
<td>Student Involvement [SI]</td>
<td>Extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class.</td>
<td>I pay attention.</td>
</tr>
<tr>
<td>Shared Control [SC]</td>
<td>Extent to which teacher gives control to the students.</td>
<td>I help the teacher to decide which activities I do.</td>
</tr>
<tr>
<td>Open Endedness [OE]</td>
<td>Extent to which the teacher gives freedom to think and plan own learning.</td>
<td>I am encouraged to think for myself.</td>
</tr>
<tr>
<td>Environmental Interaction [EI]</td>
<td>Extent to which students are engaged in field trips.</td>
<td>Learning is very important for me during our field trips.</td>
</tr>
</tbody>
</table>

### METHODOLOGY

The objectives of the current study were:

- to provide validation information about the PLACES (in terms of reliability, factor structure, discriminant validity and ability to differentiate between classrooms) when used in three different countries (Australia, India, Mauritius);
- to find out the differences in students perceptions of science environmental education from different countries; and
- to find out gender differences in students perceptions of science environmental education on the basis of gender.

The total sample comprised of 514, science students from Years 9 and 10 from three countries namely Australia, India and Mauritius of those, 153 Australian students, 295 Indian students and 66 Mauritian students participated in the study. Total sample consisted of 347 male and 167 female students. Each student responded to the actual and preferred version of the PLACES.

While carrying out the study educational pedagogy of teaching environmental education and educational systems in each country were taken into account. Following are the accounts of pedagogy employed by teachers and provided by the school authorities.
Pedagogy of teaching environmental education

Australia

This research was carried out in the state of Western Australia, where teachers are given broad guidelines by the State Curriculum Council and desired subject outcomes by the end of academic year. Teachers at school/class level have the freedom to plan activities to achieve these outcomes. The school, where this research was conducted, follows a multidisciplinary approach and tries to promote student critical thinking. Teaching pedagogy often involves students applying background knowledge across the science disciplines and from several subject areas. This exemplifies recommended reforms and trends in science education where both inter-science discipline (e.g. ecology, physics, chemistry, biology, soil science, geology) and cross-subjects (e.g. Mathematics, Science, History) approaches are viewed as better supporting concept development (Champagne, Newell & Goodnough 2003; Elliott, Oty, McArthur & Clark, 2001). This “multidisciplinary approach” also compliments Taskin’s (2003) review of environmental science literature, concluding that such approaches powerfully support successful “inquiry-based” environmental science education.

India

Until the eighteenth century, indigenous systems of education, based on religion, trade and craft, had been fairly widespread in India (Ramadas, 2003). The colonial system, which replaced them, was aimed at training clerks and civil servants. The cheapest and most accessed resource in India is the print material (Ramadas, 2003). Kumar (1986) confirms this view by saying, “in countries with limited resources such as India, textbooks are often the prime curriculum resource in schools”. The other resources available to Indian students are the teachers, whose training continues to be traditional, concentrating on elementary communication skills (Kulkarni, 1988). Environmental education in the school teaches students about the interdependence of living things within their environment and also provides insights into the orderly interplay of factors influencing environmental change. Awareness is created in students about the human demands on renewable and non-renewable resources of energy and their limited availability. School claims that pedagogy aims at both cognitive and affective behaviour modifications. An attempt is made to create awareness, transmit information, teach knowledge, develop habits and skills, promote values, and provide criteria and standards, and present guidelines for problem solving and decision making. This is usually done through both classroom and field activities, which are action-oriented, project centred and participatory process leading to development of self confidence, positive attitudes and personal commitment to environmental protection. Moreover, an interdisciplinary approach is adopted for the benefit of students. Environment is not a subject taught in Indian schools. At secondary level, environmental issues are being addressed essentially in the sciences, especially in Biology and Chemistry. They are also dealt within Social Studies.

Mauritius

Mauritius is the main island of the Republic of Mauritius, which consists of a number of small islands in the Indian Ocean and scattered within a radius of about 800 kilometers. The education system in Mauritius follows a British pattern, with a three-stage model (6+5+2) that is, 6 years in primary (Standard I – Standard VI) leading to the Certificate of Primary Education (CPE); 5 years (Form I – Form V) in secondary school leading to the Cambridge School Certificate (SC); and 2 more years (Lower VI and Upper VI) in secondary school leading to the Higher School Certificate (HSC). Subject specialist teachers at secondary level do not help promote cross-curricular links among Environmental Education (EE) issues being addressed in the different subjects. Since conducting outdoor/field trip activities is not yet a policy, EE is mainly carried out in classes. Teachers do not carry out such exercise due to the time and cost implications. Active learning strategies were initiated in the school where data was collected, which was involved in EE projects, funded by national/international agencies. In these projects, pupils identified an environmental problem in their own context. They use enquiry learning, problem solving strategies. In such tasks pupils were given opportunities to interact with relevant stakeholders, hence involved community. They also sensitised the public at large (by reporting the outcome of their work) through articles in the press. They also use Role play as a strategy to sensitize parents and community at school when they organised open day. However, several constraints were met in these projects. Some of the projects were School Compost project and School Footprint project.

RESULTS

Validation information about the PLACES

The validity and reliability information of the instrument developed in this study are presented in Tables 2 and 3. Principal components factor analysis, followed by varimax rotation, confirmed a refined structure of the actual and preferred forms of instrument comprising 40 items in 8 scales. All items have a loading of at least 0.30.
To determine the degree to which items in the same scale measure the same aspects of students’ perceptions of environmental education, a measure of internal consistency, the Cronbach alpha reliability coefficient (Cronbach, 1951) was used. For the scales of PLACES, the highest alpha reliability of 0.82 for the scale of Shared Control, and the lowest of 0.61 for the scale of Student Involvement the instrument developed is reliable for use (De Vellis, 1991).

High mean scores in both, actual ranging between 2.17 for the scale of Shared Control and 2.91 for the scale of Critical Voice on a four point Likert type scale confirm that students generally have a very positive perception of their environmental education. However, students perceive for greater positive environments and scores for preferred version of the questionnaire are consistently higher.

Table 2
Factor Loadings for Place-Based and Constructivist Environment Survey (PLACES)

<table>
<thead>
<tr>
<th>Item no</th>
<th>Relevance</th>
<th>Critical Voice</th>
<th>Student Negotiation</th>
<th>Group Cohesive</th>
<th>Student Involvement</th>
<th>Shared Control</th>
<th>Open Endedness</th>
<th>Environment Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.60</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.63</td>
<td>0.67</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.73</td>
<td>0.71</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0.77</td>
<td>0.82</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0.68</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.70</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0.59</td>
<td>0.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>0.50</td>
<td>0.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>0.54</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>0.54</td>
<td>0.58</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>0.38</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0.52</td>
<td>0.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>0.68</td>
<td>0.73</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.73</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>0.47</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>0.66</td>
<td>0.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>0.70</td>
<td>0.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>0.48</td>
<td>0.53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>0.48</td>
<td>0.54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>0.55</td>
<td>0.57</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td></td>
<td></td>
<td>0.45</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td></td>
<td></td>
<td>0.50</td>
<td>0.56</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td></td>
<td></td>
<td>0.60</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td></td>
<td></td>
<td>0.74</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td></td>
<td></td>
<td>0.69</td>
<td>0.75</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.73</td>
<td>0.75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.71</td>
<td>0.72</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
<td>0.76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.72</td>
<td>0.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.53</td>
<td>0.55</td>
</tr>
<tr>
<td>32</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.34</td>
<td>0.42</td>
</tr>
<tr>
<td>33</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.39</td>
<td>0.43</td>
</tr>
<tr>
<td>34</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.42</td>
<td>0.44</td>
</tr>
<tr>
<td>35</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.37</td>
<td>0.44</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Factor loadings less than 0.30 have been omitted.
The sample consisted of 514 student responses in three countries.
The ability of PLACES to differentiate between the classes/countries is important. The instrument’s ability to differentiate in this way was measured using one-way analysis of variance (ANOVA). The $\eta^2$ statistic was calculated to provide an estimate of the strength of the association between class membership and the dependent variables as shown in Table 3. The $\eta^2$ statistic for the PLACES, indicates that the amount of variance in scores accounted for by class membership ranged between 0.02 and 0.33 and was statistically significant ($p<0.001$) for all scales. It appears that the instrument is able to differentiate clearly between the perceptions of students in different classrooms/countries.

Table 3
*Scale Mean, Standard Deviation, Internal Consistency (Cronbach Alpha Reliability) and Ability to Differentiate between Classrooms (ANOVA Results) for the PLACES*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>St. Dev</th>
<th>Alpha reliability</th>
<th>ANOVA ($\eta^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Actual</td>
<td>Preferred</td>
<td>Actual</td>
<td>Preferred</td>
</tr>
<tr>
<td>Relevance/Integration</td>
<td>2.51</td>
<td>2.98</td>
<td>0.56</td>
<td>0.64</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>2.91</td>
<td>3.00</td>
<td>0.67</td>
<td>0.66</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>2.77</td>
<td>2.77</td>
<td>0.64</td>
<td>0.64</td>
</tr>
<tr>
<td>Group Cohesiveness</td>
<td>2.89</td>
<td>3.12</td>
<td>0.61</td>
<td>0.59</td>
</tr>
<tr>
<td>Student Involvement</td>
<td>2.89</td>
<td>3.04</td>
<td>0.56</td>
<td>0.66</td>
</tr>
<tr>
<td>Shared Control</td>
<td>2.17</td>
<td>2.75</td>
<td>0.77</td>
<td>0.78</td>
</tr>
<tr>
<td>Open Endedness</td>
<td>2.87</td>
<td>3.09</td>
<td>0.61</td>
<td>0.62</td>
</tr>
<tr>
<td>Environmental Interaction</td>
<td>2.63</td>
<td>2.97</td>
<td>0.76</td>
<td>0.71</td>
</tr>
</tbody>
</table>

n= 514 students in 3 countries *$p<0.001$

Correlations

Table 4 indicates that significant correlations ($p < 0.01$) were found among scales used in the instrument. For example, Relevance/Integration was positively related to and was positively associated with all other scales of PLACES.

Table 4
*Inter-Scale Correlation for the scales of PLACES*

<table>
<thead>
<tr>
<th>Scale</th>
<th>RI</th>
<th>CV</th>
<th>SN</th>
<th>GC</th>
<th>SI</th>
<th>SC</th>
<th>OE</th>
<th>EI</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>1.00</td>
<td>0.29**</td>
<td>0.29**</td>
<td>0.21**</td>
<td>0.23**</td>
<td>0.34***</td>
<td>0.30**</td>
<td>0.31**</td>
</tr>
<tr>
<td>CV</td>
<td>1.00</td>
<td>0.46**</td>
<td>0.37**</td>
<td>0.48**</td>
<td>0.22***</td>
<td>0.47**</td>
<td>0.20**</td>
<td></td>
</tr>
<tr>
<td>SN</td>
<td>1.00</td>
<td>0.48**</td>
<td>0.5**</td>
<td>0.26**</td>
<td>0.51**</td>
<td>0.28**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GC</td>
<td></td>
<td>1.00</td>
<td>0.36**</td>
<td>0.06</td>
<td>0.45**</td>
<td>0.19**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SI</td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.32**</td>
<td>0.47**</td>
<td>0.38**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.36**</td>
<td>0.45**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td>0.37**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
</tr>
</tbody>
</table>

n= 514 students in 3 countries **$p<0.01$

Gender differences

The associations between the students’ perceptions of their perceptions of environmental education and their gender were analysed. The gender differences in students’ perceptions of classroom learning environment were examined by splitting the total number into female (167) and male (347) students involved in the study. To examine the gender differences in students’ perceptions of environmental education the within-class gender subgroup mean was chosen as the unit of analysis, which aims to eliminate the effect of class differences due to males and females being unevenly distributed in the sample. In the data analysis, male and female students’ mean scores for each class were computed, and the significance of gender differences in students’ perceptions of environmental education were analysed using an independent t-test. Table 5 shows the scale item means, female and male differences, standard deviations, and t-values. The purpose of this analysis was to establish whether there are significant differences in perceptions of students according to their gender. Statistically significant differences were found between the female and male students on the scales of Student Negotiation, Student Involvement, Shared Control and Open endedness. In this study female students perceived their environmental classes more negotiable, involving, open ended and teacher giving them more control than their male counterparts.
Table 5
Item Mean and Standard Deviation for Gender Differences in Students’ Perceptions Environmental Education as Measured by the PLACES.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Gender</th>
<th>Item Mean</th>
<th>Mean Difference (F-M)</th>
<th>Std. Deviation</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance/Integration</td>
<td>Females</td>
<td>2.58</td>
<td>0.10</td>
<td>0.03</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical Voice</td>
<td>Females</td>
<td>2.90</td>
<td>0.01</td>
<td>0.63</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.91</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>Females</td>
<td>2.96</td>
<td>0.29</td>
<td>0.60</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group Cohesiveness</td>
<td>Females</td>
<td>2.88</td>
<td>0.01</td>
<td>0.57</td>
<td>0.56</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.89</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Involvement</td>
<td>Females</td>
<td>2.97</td>
<td>0.12</td>
<td>0.46</td>
<td>0.01*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shared Control</td>
<td>Females</td>
<td>2.33</td>
<td>0.23</td>
<td>0.67</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Endedness</td>
<td>Females</td>
<td>3.03</td>
<td>0.25</td>
<td>0.56</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.78</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental Education</td>
<td>Females</td>
<td>2.69</td>
<td>0.09</td>
<td>0.76</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>Males</td>
<td>2.60</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* p=0.01     females (n=167); males (n=347)

Country differences

Associations between perceptions of environmental education, on the basis of the country, were examined. Differences in students’ perception of the country mean were chosen as the unit of analysis, which aim to eliminate the effects of differences due to the strength of various groups being unevenly distributed in the sample. In the data analysis, mean scores for each of the three country groups were computed. Table 6 shows the scale item means and F values of the scales of the PLACES with the perceptions of students from the three countries. This analysis was aimed to establish whether there are significant differences in the perceptions of students coming from different countries.

Table 6
Item Mean for Country Differences in Students’ Perceptions Environmental Education Measured by the PLACES Scales

<table>
<thead>
<tr>
<th>Scale</th>
<th>Australia n=153</th>
<th>India n=295</th>
<th>Mauritius n=66</th>
<th>F Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance/Integration</td>
<td>2.23</td>
<td>2.64</td>
<td>2.60</td>
<td>29.47*</td>
</tr>
<tr>
<td>Critical Voice</td>
<td>2.88</td>
<td>2.98</td>
<td>2.66</td>
<td>6.51*</td>
</tr>
<tr>
<td>Student Negotiation</td>
<td>2.58</td>
<td>2.84</td>
<td>2.90</td>
<td>9.67*</td>
</tr>
<tr>
<td>Group Cohesiveness</td>
<td>2.94</td>
<td>2.81</td>
<td>3.09</td>
<td>6.62*</td>
</tr>
<tr>
<td>Student Involvement</td>
<td>2.80</td>
<td>2.99</td>
<td>2.65</td>
<td>13.14*</td>
</tr>
<tr>
<td>Shared Control</td>
<td>1.56</td>
<td>2.55</td>
<td>1.94</td>
<td>128.52*</td>
</tr>
<tr>
<td>Open Endedness</td>
<td>2.69</td>
<td>2.97</td>
<td>2.81</td>
<td>11.32*</td>
</tr>
<tr>
<td>Environmental Interaction</td>
<td>2.37</td>
<td>2.86</td>
<td>2.23</td>
<td>35.24*</td>
</tr>
</tbody>
</table>

*p<0.001.

As can be seen in Table VI, the differences in the perceptions of students from different countries are statistically significant in all the eight scales of the PLACES. Generally Indian students have more positive perceptions of their environmental education. However, statistical significant differences in all the scales of PLACES confirm that educational pedagogy and place have effects on student perceptions.

CONCLUSION

A major contribution of the present study is the development and validation of a widely-applicable and distinctive questionnaire the Place-Based Learning and Constructivist Environment Survey (PLACES) for
assessing students’ perceptions of their actual and preferred environmental education. Quantitative analysis has confirmed the validity and reliability of the questionnaire. All the scales of the questionnaire are positively and significantly correlated with each other. Statistically significant differences were found between female and male students on the scales of Student Negotiation, Student Involvement, Shared Control and Open endedness. In this study female students perceived their environmental classes as more negotiable, involving, open ended with the teacher giving them more control than their male counterparts. Students from all the three countries have statistically significant differences in their perceptions of environmental education. Generally, Indian students have more positive perceptions of their environmental education. However, statistical significant differences in all the scales of PLACES confirm that educational pedagogy and place affects student perceptions.

REFERENCES


VALUED SCIENCE AND MATHEMATICS LEARNING IN MIDDLE SCHOOLING: CONNECTING TO STUDENTS’ LIVED EXPERIENCES

David Lloyd and Kathryn Paige
University of South Australia
Australia

ABSTRACT

The research we describe here is a small part of a larger study funded by the Australian Research Council (ARC) entitled Redesigning Pedagogies in the North (RPiN), a project based in public schools in the northern suburbs of Adelaide, South Australia. We describe how a teacher of mathematics and science, who is a co-researcher with the authors, shifted his pedagogical strategies from a decontextualized textbook approach to learning to one which values students’ lifeworlds and students’ interests as organisers in the learning process within a middle schooling setting. We describe the challenges this teacher has had in designing and delivering relevant curriculum and, in the process, overcoming entrenched institutional structures and personal practices. The paper uses case study methodology to highlight a participant-teacher’s attempt to provide a rigorous curriculum for students through a transdisciplinary approach to teaching science and mathematics. Our challenge has been to develop rich descriptions of emergent pedagogical alternatives that sustain high expectations for learning.

INTRODUCTION

During the last decade an international movement has developed around the need to reinvigorate middle years curriculum and pedagogy, a movement that is referred to as ‘middle years schooling’. In Australia, research on the middle schooling debate has been undertaken by Eyres, Cormack and Barratt (1992), Cormack (1996), Barratt (1998), Thomson (2002) and Carrington (2006). Within this context, both mathematics and science learning in middle school are currently seen as problematic because of the decline in their popularity and poor take-up in senior secondary school and universities. This problem situation forms an aspect of the disengagement identified as one of the challenges for middle schooling that has been taken up by the Redesigning Pedagogies in the North (RPiN) Project, an Australian Research Council (ARC) funded study, which seeks to find pedagogical ways to integrate lifeworlds and subject discipline knowledges in ways that don’t trivialise either and with the aim of re-engaging students in valued learning. The research we describe here is a small part of the larger ARC study based in public schools in the northern suburbs of Adelaide, South Australia. We describe how a teacher of mathematics and science, who is a co-researcher with the authors, attempted to shift his pedagogical strategies from a decontextualized textbook approach to learning to one which values students’ lifeworlds and students’ interests as organisers in the learning process within a middle schooling setting.

We are aware of the complexity of trying to communicate rich descriptions of this teacher’s innovative middle schooling practices within a case study. We have tried to structure this paper in a way that describes the three-year project from which the case study emerged while providing the reader with insights into our philosophical perspective concerning sustainable futures.

The paper starts with an overview, firstly outlining the Redesigning Pedagogies in the North Project, which provides the context for the case study. Secondly it provides a middle school framework and identifies the challenges for mathematics and science learning. The third section describes the literature which informed this aspect of the project and is centred on sustainable futures, drawn from the key areas of transdisciplinarity, place-based learning and science and mathematics education. The fourth and final section describes the professional opportunities the other teachers in the school beyond the subject of the case study had access to over a three year period to inform their practices. The case study uses rich descriptions and employs the case study teacher’s voice where possible to highlight professional growth and innovative pedagogies. The paper concludes by highlighting the pedagogical challenges raised in the case study.

OVERVIEW

1 Acknowledgements: This publication is an outcome of the collaborative ‘Redesigning Pedagogies in the North’ project, funded by the Australian Research Council (LP0454869), between the Centre for Studies in Literacy, Policy and Learning Cultures (University of South Australia), the Northern Adelaide State Secondary Principals Network (NASSPN), the Australian Education Union (SA Branch) and the South Australian Social Inclusion Unit. The Research team includes Assoc. Prof. Robert Hattam, Assoc. Prof. Phillip Cormack; Prof. Barbara Comber; Prof. Marie Brennan; Dr. Lew Zipin; Prof. Alan Reid; Dr Brenton Prosser; Assoc. Prof. Helen Nixon; Mr. Bill Lucas; Dr. Faye McCallum; Ms. Philippa Milroy; Mr. Sam Sellars.
The RPIn Project is an ARC funded project linking the University of South Australia, the Northern Adelaide State Secondary Principals Network, the Australian Education Union and the South Australian Government Social Inclusion Unit. The project officially commenced in July 2004. It is the largest of its type in Australia and currently involves 10 schools, 30 teacher-researchers, 12 university researchers and 1000 students. The thirty teachers represent a diverse range of ages, teaching experiences, subject specialities and time teaching. Three of the teachers identified an area of expertise in science and mathematics and it is working with these three teachers over three years that the data has been collected. In this paper we illustrate this data through one of these case studies.

This project has been developed as a response to a set of interrelated problems facing Northern Adelaide State schools including concerns about falling retention rates, low post-compulsory certification, and low university entrance. This region experiences high levels of poverty, early school leaving and youth unemployment, as well as reduction in traditional pathways due in part to the dramatic decline in Adelaide’s manufacturing industry over the last fifteen years (Thomson, 2002). One of the central aims of the RPIn project is to challenge “deficit” views that teachers and others may have of disenfranchised communities serviced by the Northern Adelaide State schools. This disenfranchisement arises from the lack of connection between the traditional secondary school curriculum and the lived experiences of many Northern Adelaide young people. The RPIn approach explicitly confronts the deficit (which results when ‘elite cultural capital predominates’ in curriculum planning) and instead assumes that “people are competent and have knowledge, and their life experiences have given them that knowledge” (Gonzalez & Moll, 2002, p.625). That is, Northern Adelaide young people come to school embodying cultural assets for learning, which can be used in the curriculum.

The project aims to help teachers understand their students’ lives more clearly and their school communities more deeply, so that they can redesign their pedagogy to provide a relevant and more equitable curriculum. It aims to build curriculum and Pedagogical Practice that engage young people’s ‘funds of knowledge’ (Gonzalez & Moll, 2002; Moll, Amanti, Nett, & Gonzalez, 1992) that arise from their lifeworlds and that is consistent with the concerns of their communities, and that provides academic success in the mainstream curriculum.

The RPIn research question was:

How can a university-school network collaboratively build professional and scholarly knowledge and practices for middle schooling curriculum and pedagogy that engages young people’s lifeworlds in public schools of Adelaide’s northern area?

Our challenge, as researchers, was to support a small group of mathematics and science teachers to incorporate sound pedagogical practices into their classroom through action research cycles. The case study reported in this paper arises out of this broader project.

Middle schooling

We are using the term 'Middle schooling' to refer to a quite specific set of beliefs and practices around the needs and abilities of early adolescence (Carrington, 2006, p. 34). Key themes and strategies consistently emerge from middle schooling literature about best pedagogical practice and include:

- a separation of the middle years from the rest of the school and treating them in a way that provides a seamless transition between the early and mid-primary and later secondary contexts;
- establishing teaching teams and/or subgroups to enhance teacher-student relationships;
- devising integrated/transdisciplinary and negotiated curriculum;
- using ‘authentic assessment’ of rich learning tasks (Hattam & Prosser, 2006);
- the focus on pastoral care and social outcomes as well as academic achievement;
- community orientation and a focus on ethical awareness;
- fostering academic rigour;
- increasing student engagement (Prosser 2006).

These key themes and strategies, which Carrington (2004, p.71) calls ‘signature practices”, are appropriate for both teacher and student.

Teaching mathematics and science in middle school

While Australian students achieve average or above average results in the Program for International Student Assessment (PISA) studies (OECD, 2006), the students in the northern school of Adelaide are below average and under represented in science/mathematics related courses at universities. The PISA report suggests that a significant factor for underachievement is the socio-economic status and students’ home resources. This state of affairs is true for a majority of students who attend Adelaide’s northern suburban schools.
This presents challenges for all areas of learning, but in particular for science and mathematics which are considered by Northern Adelaide students to be only for the “brainy” (esoteric), and difficult for average students. There are curriculum, pedagogical and school political challenges to overcome, as well as the stress of additional preparation and risk taking by teachers. To shift from a traditional approach of transmission, text-based and test-assessed curriculum to one that is negotiated, emergent and authentically assessed is a task needing a lot of courage. However, this approach does seem to address what Jim Peacock, Australian Chief Scientist, sees as three key ideas important in school science: science education shouldn’t be prescriptive – it is about the ‘spark of excitement’ that stems from discovery; open-ended tasks and relevance are vital. Students need to understand the world around them and make rational decisions on important issues and teacher confidence and professional development is just as important as the students’ learning materials (Tytler, 2007, p. iii).

Reinvigorating mathematics and science learning has been the challenge for the mathematics/science teacher from a Northern Adelaide Public Secondary School whose story we relate here. He had the challenge of redesigning curriculum, rethinking pedagogy and engaging middle-school students in deep and valued science and mathematics learning. In the next section we look at the ideas from the literature that has informed the “redesigning of curriculum and pedagogical practices”.

Research literature that informed the study

In the first phase of the project (during 2005) teacher participants were provided with a set of readings for supporting innovative changes in classroom practice involving funds of knowledge (Gonzalez & Moll, 2002; Moll et al., 1992), place-based education (Cameron, 2004; Gruenewald, 2003; Smith, 2002), turn around pedagogy (Comber & Kamler, 2004; Lingard, Mills & Hayes, 2000; Maney, 2005), sustainable futures (Eckersley, 2002; Lloyd, 2005), and popular culture (Alvermann, Huddleston & Hagoood, 2004; Kinzer, 2003). These readings have been operationalised by way of four themes: representations of northern Adelaide; making community curriculum; youth, culture and identity; and sustainable futures. The teacher in the case study described here (and other teachers whose work has informed us) has relied primarily upon aspects of the sustainable futures materials, namely, transdisciplinarity, place-based learning and the implications for science and mathematics learning. We briefly review these three areas.

In order to make science and mathematics meaningful the subject specific concepts and processes must be connected to students’ lifeworlds. From a transdisciplinary perspective, students’ interests and issues come first and the necessary knowledge, skills and understandings associated with the interests or issues are selected as necessary in order to arrive at a better understanding of the interest or issue for resolution. This approach constitutes strong connectivity and is what Freire calls generative or topical themes. Generative themes are negotiated with the students and arise from everyday life. Topical themes can be gleaned from the news and other forms of media and are those that have local, national or international significance. The types of topics that are usual in school settings have Academic themes that are generic, not local and are often textbook based and define the traditional subject disciplines (Shore, 1992).

Whilst much has been written about integrated curriculum (Venville, Wallace, Rennie & Malone, 2002) there is less about a transdisciplinary approach. The key difference between such terms as multidisciplinary, interdisciplinary, integrated curriculum and a transdisciplinary approach is the notion that transdisciplinary curricula are issues-based. Balsiger (2004, p. 407) states that transdisciplinarity is a scientific approach to understanding the world with a strong orientation towards societal problems and Pohl, (2005) says that “one aim of transdisciplinary research is to get natural and social scientists to collaborate, so as to achieve an integrated view of a subject that goes beyond the viewpoints offered by any particular discipline” (p. 1159). Lawrence and Despres (2004) add to this, arguing that the reason the human race cannot deal with some issues is not just due to their complexity, but also to the compartmentalisation of scientific and professional knowledge and to a lack of collaboration between discipline areas. Transdisciplinary approaches deal with real world topics and generate knowledge that addresses societal problems but also contributes to their solutions (Balsiger, 2004). The narrow vision of discipline-based experts does not address fundamental issues but only topics isolated from their societal contexts. Much of science and mathematics that is taught today in schools is the antithesis of a transdisciplinary approach and more in line with the narrow topic centred approach within particular disciplines (Paige, Lloyd, & Chartres, 2008).

Student interests and concerns are quite often connected to aspects of science and mathematics and in these situations the science and mathematics can be drawn upon to help them come to a better understanding of these interests/concerns and to the resolution of problems embedded in these interests and concerns. While this approach cannot occur all the time in science and mathematics classes, we believe it should do so often enough for students to see the connectivity of these learning areas to their lifeworlds. There are certainly many aspects of the physical and biological environments that can provide authentic environmental contexts for teaching and learning mathematics and science. Of course most issues/interests are integral in nature and require the
application of the social, cultural and political aspects as well as scientific and mathematical ways of knowing. Jucker (2002) suggests that there needs to be rigor within learning areas as well as across them, and work by Sterling (2001), Laszlo (2006), Lowe (2005) and Capra (2002) suggest that teachers need to see the world in a more holistic way if they are going to make sure that future generations have a world worth inhabiting in terms of biodiversity, quality of life and fairness between and within generations. There are many issues that provide the opportunities for students to explore how mathematics and science can be used critically to make sense of their worlds. Hodson (2003) makes the point that school science needs to change as it no longer meets the needs, interests and aspirations of young citizens and suggests the science curriculum be orientated towards socio-political action. Mathematics by way of a numeracy lens (Zevenbergen, 2004) also connects mathematics to students’ lifeworlds.

The challenge to using a transdisciplinary approach in an educational setting is that each of the disciplinary aspects that are needed to address transdisciplinary tasks require conceptual and skills development to a level where they can be confidently applied to complex lifeworld situations. There is a need for the teacher to carefully structure and empathetically manoeuvre learning events so that deep and rigorous learning can occur, and this requires strategic (school-wide) and thorough (class) planning. As pointed out by the Vennille team (2002, p. 53), what is required is a pragmatic approach that embraces the established disciplines and recognises, and attempts to meet, the needs of pupils, the school and the local community.

A second theoretical perspective is place-based education, which grounds learning in local phenomena and students’ lifeworld experiences (Smith, 2002, p. 286). As Dewey points out the great waste in schools comes from students’ inability to utilize the experiences they get outside the school in any complete and free way within the school itself (quoted in Smith, 2002, p. 586). Students in the North spend most of their time in their local district and seem to have an attachment to it despite the negative press “the North” often gets. These negative stereotypes that circulate about the northern suburbs are misleading. Students, teachers and schools have shown in the RPIN study that they are proud of their location, are motivated to achieve and are committed to building safer and sustainable communities. Individual ‘being’ and ‘coming’ rests, in part, on where the individual lives and what connects that living place to the individual. Groundwater-Smith, Mitchell and Mockler (2007) write that “our social histories and our social geographies are inextricably linked” (p. 5). Students’ living places are central to their lifeworlds and should not be invisible in the school curriculum but seen as central and “an important determinant of access to life chances” (Groundwater-Smith, Mitchell, & Mockler, 2007, p. 6).

Gruenewald (2003) argues that we each have to develop a sense of place and that currently education is about standardising the educational experience of students from diverse cultural and geographical backgrounds so they can compete in the global economy and that this reduces the importance of a student’s place as a primary experiential and educational context. Such an approach separates learning from reality and therefore diminishes the relevance of schooling to the students’ lived experiences. Important tasks for education such as “the continual bringing forth of a world through the process of living” (Capra, 2002), environmental sustainability (Sterling, 2001), and our connectivity to cosmos (Laszlo, 2006) become academic rather than grounded in lived experience. It seems to us that place as a learning focus isn’t an option, but a necessary ingredient in authentic, life forming, deep learning.

Recognising the connections we each have with the natural and built environment is an important key dimension of a transdisciplinary approach to teaching and learning. We also argue that the study of place can help increase student engagement and understanding of the mandated curriculum through multidisciplinary experiences that are deliberately connected to local places – students’ living spaces – and can contribute to wellbeing of self and community life. Although it is likely that making connections to students’ lifeworlds will reveal both the “light” and “dark” sides of life, it is important at least initially to not over politicise place-based pedagogy as it “can create fear anxiety and hopelessness in learners that makes them less capable of taking socially or ecologically appropriate action” (Gruenewald, 2003, p.7). The challenge for the teacher is to pursue pedagogical strategies that “support the learners’ developmental readiness for engaging in complex ecological/social themes” (Gruenewald, 2003, p.7). Woodhouse and Knapp, (cited in Gruenewald, 2003) describe several distinctive characteristics of place-based learning: it emerges from the particular attributes of place, it is inherently multidisciplinary, it is inherently experiential, it is reflective of an educational philosophy that is broader than “learning to earn”, and it connects with self and community.

The third set of readings focused on science and mathematics learning. At present, with the knowledge dominated curriculum, we know teachers largely adopt a transmissive style of pedagogy and the majority of students fail to understand science, and increasingly describe it as “boring” – the outcome of a combination of low interest and too high a cognitive demand (Fensham, 2003, p.18). Goodrum (2006), Goodrum, Hackling and Rennie (2001), Rennie (2006) and Tytler (2007) have all pointed out the failure of many teachers of science to provide relevant and engaging science experiences for their students. Science courses that connect to student lifeworlds, on the other hand, are “located in the multiple societal contexts within which citizens are involved - at home, in their neighbourhood, in their work, at leisure, and as members of local, regional and national communities (Fensham, 2003, p. 8) and are situated, engaging, and relevant.
If school science curriculum is to connect to students’ lifeworlds, issues and future expectations (Eckersley, 2002; Lloyd, 2005), it must go beyond the technical and the particular and embrace a broader understanding of school science. Aikenhead (2002) argues that the future of science education lies in scientific literacy for an informed public. A scientifically literate person understands more about science and its processes, recognises its place in our culture and society, and is able to use it in their daily lives (Goodrum, Hackling & Rennie, 2001; Goodrum & Rennie, 2007; Tytler, 2007).

A similar argument can be made for mathematics (mathematical literacy or numeracy). Much mathematics is taught by telling but needs to be taught in such a way that lets “students make sense of the mathematics they are learning” (Van de Walle, 2006, p. 14). When connecting mathematics to students’ lifeworlds teachers can use the term “numeracy”. Numeracy in this context involves choosing and using mathematics for a purpose rather than having a range of different numeracies, people operate in and across a variety of dimensions of numeracy which serves the ideas of thinking and working mathematically (Forrest, 1997; Frankenstein, 2001; Johnson, 1994; Scott, 2000). This approach connect with the needs of a transdisciplinary curriculum approach. Aspects of numeracy which meet the needs of a transdisciplinary/place-based approach include the; functional dimension, socio-cultural dimension, technological dimension, and critical dimension.

Dealing with complex, real world problems requires a significant shift in school curriculum and the way mathematics and science concepts, processes and values can be drawn upon in learning. Issues such as those associated with student lifeworlds need a holistic systems style of thinking so students can deal with complex webs of relationships.

PROFESSIONAL DEVELOPMENT OPPORTUNITIES

To support participating teachers in carrying through the RPiN objectives the academic team provided a number of professional development opportunities. An initial whole day session set the scene where teachers were provided with input from key researchers on topics such as place based learning, using futures as a way into students’ lifeworlds, generating metaphors of their school, making community curricula and teachers as interviewers. This session also involved teachers interviewing a colleague to collect their professional biographies. This initial day was followed by a series of interactive roundtables. The general aim of these sessions was to provide opportunities to problematise theory and practice. Each roundtable discussion was tape-recorded and conversations transcribed, providing very rich initial data. Teachers prepared for each roundtable by completing a research task. These included researching their community; representing who they were and where they came from; collecting artefacts that would prompt discussion about living and teaching in their school community; reflecting on their pedagogy; using futures imaging to project into a preferred educational future; and exploring youth and pop culture.

There were four strategies planned for teachers’ participation in roundtables. Firstly, teachers were provided with copies of current literature which critiqued pedagogical practice; secondly, teachers mapped their current practice; thirdly, teachers were guided in the use of student work samples and achievement testing to develop benchmarks of practice; and fourthly, teachers were provided with professional development for undertaking educational action research.

There were expectations of the teachers who were involved. They were invited to keep a reflective journal of critical incidents, quotations, to video or audio-tape significant teaching moments, collect evidence of student-understanding (e.g. artefacts, work samples, assignments) and to develop detailed research plans. The two key tasks at the end of the first year were to firstly identify a research question and to undertake action research on an aspect of their pedagogy, and secondly to design and implement a unit of work which would engage their students.

Teachers were to use the information arising out of the professional development experiences that were central to the roundtables, the current literature and the daily experience of providing relevant and engaging learning for their young middle school students, to identify a critical aspect of their pedagogy to research. These aspects could include engaging youth sub-cultures, mapping community funds of knowledge, investigating young people’s involvement in new technologies and implementing an integrated/transdisciplinary curriculum. After six months of the project teachers with common areas of expertise and interest were linked with university academics to examine the following four themes: youth culture and identity representations in the North; multi-modal text creation; sustainable futures; and making community curricular. The teacher (David) who is the focus of this case study, opted for the sustainable futures theme which explored a transdisciplinary approach to science and mathematics, with a focus on educating for ecological sustainability.

Professional learning communities were also built through interaction at the roundtables as well as participation in annual conferences (AEU, SASTA, and Middle Years of Schooling2). In the first conference the teachers were observers, but in the second and third conference teachers presented their research projects to a

2 AEU - Australian Education Union; ASTA - South Australian Science Teachers’ Association; 3rd International Middle Years of Schooling Conference, 2006, Adelaide, South Australia.
wider audience. Opportunities for professional dialogue between teacher-researchers and university researchers provided insights into building middle schooling pedagogy.

In addition, regular meetings were held in school sites during the second year to refine research foci, provide support in project design and share perspectives on research developments and challenges faced while implementing the new approaches to teaching and learning. As a part of the action research cycle, teachers either continued with the same research question (and same unit of work) but involving a different cohort of students or they selected a related research question to probe.

CASE STUDY: DAVID’S STORY

David’s story was selected because it involved the implementation of a transdisciplinary unit of work where students’ lifeworlds and student negotiation were central to meeting the science and mathematics learning outcomes within a middle school setting. In his first iteration of action research, David focussed on a unit of work from a science perspective but in the second iteration of the same topic he took a mathematics perspective. Learners in this case study have engaged in deep learning, and the action research has impacted on both the teacher and students. However, it is the teacher’s learning that is the focus of this case study.

The case study has been structured around school context, middle school structure and curriculum, the classroom and action research project. The classroom aspect has used a modified framework introduced in the middle school discussion (see page 2). The case study concludes with a summary of the challenges encountered and suggestions for possible ways forward.

School context

David, the teacher in this case study, has been a secondary school teacher of science and mathematics for 13 years. He is currently a coordinator of mathematics and numeracy. He has worked primarily in disadvantaged northern suburbs schools and has a strong commitment to social inclusion and social justice and equity. He has just commenced a Doctor of Education Program. For this study David was situated in two schools. In 2005 he was at Sefton High and in 2006 he moved to the Paloma School (names of schools are pseudonyms), which is one of the few R-12 schools in South Australia. In both locations there is a disproportionately high level of complex and aggregate disadvantage within the school population. Many issues arise from the poverty, generational unemployment, high youth unemployment and individual and family transience. The area immediately surrounding the schools comprises semi-detached public housing and there are a large number of single parent families. The schools have a long history of commitment to working with and supporting students at risk of not completing a full secondary education. Current strategic directions for both schools included raising the standards in literacy and numeracy. Sefton High aimed to provide success-oriented student pathways in order to prepare students for lifelong learning, to offer a broad, balanced relevant curriculum, to improve access to, and develop information technology skills. Over the period, 2005-2007 the Paloma R-12 school was involved with Futures Connect and aimed to improve student attendance, retention, engagement, resilience student voice and smooth transitions within the program.

Whilst the data for this case study was collected in two schools the emphasis has been on the transdisciplinary nature of the classroom practice rather than the similarities and differences between the two schools. Hence the student profile and middle school structures will be drawn from the second site, Paloma School, where the teacher has spent the last two years.

The students at Paloma High come from a wide range of cultural backgrounds representing at least 22 different nationalities. Consequently there are significant enrolments of students with non-English speaking backgrounds. Paloma High also has one of the largest enrolments of Aboriginal students in the metropolitan area.

Middle school structures and curriculum

Paloma is a school of approximately 1100 students from Reception to Year 12. It consists of three sub-schools; Junior (R-6), Middle (7-9) and Senior (10-12). Each sub-school has a co-ordinator to manage behaviour and to innovate curriculum. The Middle School priorities focus on attendance, engagement and achievement. Middle School class sizes are smaller than the norm, at 24 students. Year 7 home group teachers teach their class for four subjects and Year 8 home group teachers teach their classes for two subjects.

---

1 Futures Connect is a Government of South Australia, Department of Education and Childrens’ Services initiative. The Futures Connect Team concentrates specifically on Youth Engagement issues including Career Development, Transition Services, VET-in-Schools, Enterprise & Vocational Learning, Curriculum Reform, Australian School Based Apprenticeships (ASBAs), and Workplace Learning.
The middle school curriculum (Years 7 – 9) covers core subjects from all eight Areas of Study\(^4\) with the LOTE option being Indonesian. Students have the opportunity to pursue a specialist sports focus. The implementation of the Year 7 – 9 curriculum is underpinned by explicit Middle School teaching and learning methods. The emphasis in Years 7 – 9 is on collaborative teaching: teachers working in teams together to enhance curriculum and students’ learning. There is a strong commitment to providing programs that develop student resiliency and promote anti-bullying.

The rationale for school reform at Paloma is based on three key premises/foci:

1. Providing vibrant, challenging, rigorous learning environments;
2. Improving attendance, retention, engagement; and
3. Connectedness – sense of belonging, being liked and valued.

The case study that follows embraces all three.

David’s classroom

The key pedagogical foci of David’s classroom include connecting to student lifeworlds through community projects, interdisciplinary approach to teaching mathematics, working collaboratively with other colleagues, providing opportunities for students to negotiate, connecting with parents/home and engaging students by using mathematics in the real world.

David involved the students in a rich task within their science lessons in 2005 and used a similar rich task in a different school in 2006 within their mathematics lessons. After interviewing at least one family member about what they knew about the street they live on and what they felt was needed around the area, the students’ brief was to identify what they thought was needed in the community and then, in small groups, chose a concept and designed and built a model. The unit was titled “Your community: What is missing?”

The projects the students constructed included a skate park, crèche, grid iron playing field, sound studio and fair ground. When interviewed at the end of 2007 David’s was asked what his current focus in teaching involved was, David made the following statement.

“So mine is community issues and place-based education, and that’s what I’m looking at, so I suppose I’m a lot more interested in what’s happening in the local community for the school now, and how I can link that into the kids’ learning.”

A slightly modified list of the pedagogical practices identified earlier in the paper has been used as a framework to describe the classroom.

1) Establishing teaching teams and/or subgroups to enhance teacher-student relationships

David worked with a range of teachers, particularly in the first year, when teaching the topic through a science lens. He worked with the Technology Staff, the pathway teacher and the art teacher. When asked if there were difficulties with this coordination, David responded in the following way.

“No, they didn’t actually think I was encroaching on their area, which was really good. They got a little bit involved. They helped me, when it came to some of the materials and stuff like that, cutting up to size and so forth, so that was really good that way, but no, they thought it was fine, and while they didn’t give very much like practical assistance, they still left it all up to me, but they liked the idea.

The opportunity to co plan with others in an integrated middle school sense was a strategy that David felt would be part of future school structures.

One of the other things that’s come out of it is the pathways teacher. When I actually brought this to the staff, the pathways teacher who’s got our special education class, he’s at the moment, the only teacher that’s got a true middle school where he’s got his kids for four or five lessons, and he came to me and afterwards said ‘This is fantastic, I’m going to use this for the pathways kids now’, so he could see a lot of use in it and stuff like that for an integrated middle school type thing. Next year at the school, it is going to be integrated, it is going to be a middle school focus school, that it was good to actually trial this in the school and see what it was like for next year.

2) Devising integrated/transdisciplinary and negotiated curriculum

In David’s unit of work, whether focused on science or mathematics, it could be considered an integrated topic. The rich task involved students surveying members of the community and determining which facility was

\(^4\) English, Mathematics, Science, Technology Studies, Physical Education, Studies of Society and Environments (SOSE), The Arts, Languages other than English (LOTE)
most in need. The task involved students using a mathematical lens to organise the data, calculate scales, explore and measure different types of angles and lengths, and tally how much the project would cost to build. A scientific lens explored the properties of materials and flora and fauna of the local area. For design and technology the students designed, constructed and critiqued the completed model. For literacy and numeracy they constructed surveys. “Your community: What is missing?” was an integrated unit of work with clearly defined outcomes for each learning area. David made the following comments about this unit.

*It happens a little bit, like when I did my project last year I actually linked in with the English teacher, so the kids ended up doing a letter, they were starting to write a letter to the Council about what they had done, so it linked in that way with a bit of genre writing.*

The students negotiated such things as who to work with, which facility to choose, and the construction materials they wanted to use for the different models. A focus of David’s unit was developing students’ confidence to solve problems for themselves.

3) Using ‘authentic assessment’ of rich learning tasks.

Using the completed models and rubrics for peer assessment complemented the written test at the end of each unit of work. Assessment through exhibition as described by Shirley Bryce Heath was also a new strategy for mathematics. Students shared their models and PowerPoint presentations with students transitioning from year 7/8 and at conference presentations. The focus on investigations broadened the assessment strategies and engaged students in reporting about how they were thinking and working mathematically and scientifically to solve a problem.

4) Being community orientated and focusing on ethical awareness.

The models that the students built were based on surveys collected in the community. Looking outside the school for opportunities to connect with student lifeworlds in the community is the basis of place based education. David’s learning experience was intergenerational, multidisciplinary and part of it set outside the classroom boundaries. Working with parents in the shed, contacting the council through letters and using the expertise of graffiti artists all incorporated aspects of the students’ life world and making greater connection to community. And most importantly the students were developing a connection to place and sense of belonging.

5) Fostering academic rigour

David was very clear that the mathematics and science would be embedded in the rich task. At presentations he indicated that when there needed to be some explicit teaching he asked the students to bring in their text book so he could cover a concept. This was done on a needs basis, for example, when scale and ratio was required to construct a plan that would be the basis of their model. Explicit teaching of mathematics also involved measurement, angles, cost of construction and budgeting. He also tracked students’ learning in spatial sense and geometric reasoning and engaged the them to think and work mathematically though constructing and using rotograms to estimate and replicate angles. In the first year, science that was covered included properties of material, natural and manufactured materials, corrosion of metals and the physics of ramps. Students made the following comments about their learning:

Erin:  *I learnt the cost of how much everything would cost, and it cost $700,000 to build it I wrote down how big and how much land I’d need, and how many workers I’d need and all that; how many to hire the staff that would work there.*

Thomas:  *Well first I’ve learnt how much it would take up, how long it would take. The project – it took six weeks – so it would take about three years nearly. After that we seen how much the paint would cost and that, and it came around $50 for white paint, blue paint, and green, and to get the professional graffiti artist to do it, it came around $200.*

6) Increasing student engagement

The unit of work connected students to their life-world through the focus of identifying what they thought would enhance their community and involved interviewing members of their family and community. Working on a project collaboratively saw students concentrating in lessons and not knowing where the time had gone. David tells of students working for 8 or 9 hours on the weekend, being engaged during last lesson Friday and coming to work on their models voluntarily during lunch time. All evidence of the increasing engagement of students.

*On some of the lessons where the whole class was working through, we’re running for 105 minutes, when I say to them that there’s ten minutes to go, ‘Right, only got ten minutes to go, you need to start packing your stuff up’, and they sort of ‘Where did the time go?’, ‘there you go, that’s good’.*
It was clear that the context in which David was working, engaging students in work in mathematics or science classes, was challenging. David described the initial student attitude as uninterested and unwilling. This makes the success of the unit all the more significant and indicates how a learning experience involving mathematics and science investigations through model making had resulted in students being engaged in meaningful learning over a series of lessons in a six-week block. In describing the success David made the following statement.

*The engagement, especially in the model work … that was fantastic. I was really pleased. This is including kids who would sit back and pretty well do nothing, for a lesson and they were getting involved, they loved the hands-on stuff, they loved thinking about different ways of using materials to show what they wanted, and they loved being able to build a model of something that they love, especially the skate park and dance studio. I mean you’re talking about boys here who I almost have to…. use a crowbar to get them to open their book.*

Another example of engagement that infiltrated many of David’s lessons was the focus of conversations about how mathematics is used in daily life. Exploring mathematics across the curriculum ensured students could see the relevance of the mathematics that they were learning for the long term.

*David: One of the easy ones … is wages and so forth. You just ask kids ‘So who’s got a part-time job?’ ‘Yeah, I do and I do’, and you say ‘Do you mind telling me how much you actually get paid?’ and a lot of the time they’ll tell you, and then you use that, those figures, to calculate their wages and so forth, and actually show them how to do it, and they get into, they go ‘Oh!’.*

The other key area in which David engaged students was through the challenge, “Whatever career you can think of I will help you find the mathematics needed”. David described the resulting interaction in the following way:

*I had actor … I said ‘Sorry, you need it just to be able to do contracts and actually work out whether what you are getting paid is going to rip you off. If you get a percentage of the profits, how much are you going to get?’*

*Then they said ‘OK, how about a professional sports player?’ Same thing with the contracts around like that. Yeah, angles on the field and your own statistics, rankings.*

*They will say to me ‘Where is maths in this?’ like a lot of the girls will say ‘Where’s maths in hair dressing?’ Ratios for the colours and perming solutions … and I’ve also said to them ‘Look, if you’re a hair dresser it won’t be long before you’re managing your own business anyway, and you’re going to have maths all over the place.’*

*So that challenge is out to the kids. One went outside of Australia to a third world country, and apparently there are people in India who will come along and offer to clean your ears for you, he’s heard about, and he said ‘Where’s the maths in that?’*

### David’s action research project

As a member of the RPiN project team, David was also expected to carry out an action research project focusing on an aspect of his pedagogy. He saw an opportunity to combine the RPiN research with completing a Masters of Education. His thesis involved writing up the research, focusing on using the local community to improve Year 9 students’ engagement in mathematics. The title of his action research project was *Making Community Curricular: Connectedness in Year 9 Mathematics*. The research challenges the notion that much of mathematics pedagogy in year 8/9 is based on textbooks. David’s research was well informed by the relevant literature much of which was provided during the RPiN Round tables. Areas such as critical numeracy, place based education, Funds of Knowledge, democratic processes and connectedness provided a sound conceptual framework for his analysis.

The action research project involved documenting the work of small groups of students who collaborated in a mathematics class to problem solve the construction of a model of a desired community facility. This rich task was the basis of the pedagogical innovation David was researching. David used entries in teacher journals and student artefacts as the main source of data. The use of photographs of students’ models and accompanying text was a powerful way to communicate the student learning outcomes.
The findings from the study successfully demonstrated that connecting to student’ lifeworlds, negotiating boundaries and incorporating explicit mathematics concepts and skills within a rich task resulted in motivated students in mathematics.

CHALLENGES

From the analysis of the data from interviews and conference presentations there were several challenges for teachers and schools that emerged. What seems most problematic was the ability to sustain or continue to evolve the innovative pedagogy within the context in which the teachers were working. The challenges have been organised around the following headings: school structures and processes, deep and rigorous learning in mathematics and science, working differently and future directions.

School structures and processes

The literature indicates the need to structure middle schools differently. Whilst the schools had middle school structures they were still constrained heavily by a rigid time table and senior secondary demands. The importance of co-planning and working in interdisciplinary teams was regularly highlighted by the teachers but the frustration of workload and the implication that the planning meant extra meetings after school restricted the opportunity for collaborative team-teaching in all settings. David made the following statement about this.

That one would mainly need to be finding time to get, for the teachers to be able to meet. You get some teachers who will say ‘Well we’ll meet after school’, but then other teachers go ‘But I have two or three meetings after school anyway, and I don’t want to stay around for another one to do that’, so that makes it a bit difficult.

The teachers commented that they could innovate because they were provided with discussion and planning time, and were supported by university educators. The teachers devised units using different lenses and ways of knowing, including mathematics, science, English, SOSE and Design and Technology but they all worked alone and the integration came from their construct of each of the learning areas. Teachers rarely have more than one subject with students and there was no attempt to team-teach or present integrated topics planned by a team of teachers.

The majority of lessons over a one-term period were allocated for students to complete rich tasks. David commented on how much longer it took to present a topic with strong connectivity than anticipated. Due to timetable restrictions he was unable to teach the same class for two different learning areas. For this to be more successful David felt it would be more productive to teach students for both mathematics and science. The challenge for schools is to find the will and the mechanisms to support innovation and collaborative planning and teaching.

The final point refers to budget. Teachers needed access to resources not traditionally required in mathematics and science lessons. David notes that delivering transdisciplinary topics which provide rich tasks as the basis of middle school classes requires a budget that provides for this added complexity. Access to suitable information technology (IT) was a frustration for all teachers.

A key point in sustainability of the innovation is being able to replicate the connectivity idea with other year levels (with more than one class and with other subjects) to ensure that the transdisciplinary unit of work the project teachers undertook was not a one-off but an integral part of all students’ middle school experience. David indicated that it was extremely difficult to expand this approach within the then current structures. He stated that school structures can support the development of a professional learning community, but current timetabling arrangements, the silo mentality to curriculum and the influence of the senior school inhibit the development and functioning of interdisciplinary teaching teams and integrated curriculum. The challenge for both teachers and the schools are to find ways to build interdisciplinary teams that can support the needs of colleagues and the transdisciplinary curriculum.

Deep and rigorous learning- a challenge

The group of teachers involved in the program were experienced junior secondary science and mathematics teachers who were well aware of the importance of covering content in the middle years and “making inter and transdisciplinary units rigorous”. What was interesting for David in the first year was that he felt that the science was lost in the rich task. But the second year when he used a mathematics focus he was much more explicit about student-learning in science while thinking and working mathematically. The students were told which lessons to which lessons they were to bring a given text book so that required information and skills could be
explicitly taught before being applied in a practical sense. In relation to this David made the following statement.

Yeah, they're quite used to that by now, and I think it's also a case that while there's still some textbook stuff in there just to get them the basics, like there's something they've never seen ... and it's totally brand new to them, you've still got to use the textbook and you've still got to use the whiteboard to actually explain to them how it goes, but I don't use the textbook anymore to almost grind them into the ground. I will use, once the textbook has been done and I feel that they're picking up the concept, I just say 'The textbook can go away for a while, let's start seeing where these things can actually apply to real life situations.

The emphasis on thinking and working mathematically and in particular problem solving was critical for student engagement. The ongoing dilemma continued in which a balance need to be sought between the rich investigateable tasks which involved students applying the knowledge they had gained and the need to build on the content covered at the end of each academic year in order to ensure viable options for career choices in the senior years of schooling. The continuing question is how can teachers ensure students cover the content of year 8 mathematics and science whilst participating in investigations? David commented on how he uses two strategies for assessment. One involved traditional tests and the other involved the assessment of directed investigation. It is interesting to note that the test results were not greatly improved. In relation to this, David made the following statement.

That's an interesting one – if I still do a test, the test results don't improve too much, they don't actually change, but if I do it through a directed investigation or an assignment, then yes, the kids actually put [effort] into it, and they really show up.

The other comment in this section involves the importance of ensuring students can see where the mathematics and science they are learning link with their daily lives. Being numerate and scientifically literate in today's society is not negotiable and David's focus on connecting to students' personal well being, part-time work, and career trajectory on an on going basis was crucial for this to occur. The challenge was and is for this to be done on a broader basis in an effort to maintain students' interest and future enrolment in mathematics and science.

Working differently

While planning for learning is central to teachers' work, it was an undervalued area among many of the RPiN teachers. This is not suggesting a deficit view among these teachers, but rather the intensification of teachers' work, which, for survival, required, rationalising what can and cannot be done and placed the urgent and pressing at the top of the "jobs" list. When responding to a question about whether working differently is sustainable David made the following statement.

Whilst it is more energising and so forth, however I do admit to getting very, very tired on occasions because of the extra planning and so forth. I don't actually mind doing that, and in my situation considering I've only really got year 8 Maths and year 9 Science to do it for, it's actually quite easy to do it, but I can see a teacher who's say in three or four classes at 8 and 9 trying to do this, and if they are all different classes, then they will get incredibly tired.

Working as a reflective practitioner involved more planning than merely relying solely on mathematics and science texts. The challenge for schools is to provide support and incentives for teachers to plan collaboratively to factor this work into their workloads. Maintaining this level of professional learning and reflective practice is a challenge for the future. The normal work demands and embedded structures and procedures made thinking outside the square (that is being a reflective practitioner) demanding and unsupported. Day to day teaching proceeded out of habit and tacit understanding of teaching and learning.

Thinking for the future

Thinking for the future involves two aspects, one in terms of classroom vision and the second in terms of careers trajectory. Firstly the structure of how best to provide connected learning experiences through blurring the boundaries of learning areas is an ongoing problem to solve. In connection with this David said,
I think one of the things that would be really good if it happens in schools, is instead of small little topics for each subject almost, the kids do a really broad topic, say water management, and they look at it [water management] from the Maths, Science, English, S&E.

It is interesting that David has thought about other topics that could be incorporated into broadening mathematics but as yet is to try to implement one. He suggested the possible example of the Olympic Games as a topic for 2008 and linking it with the Beijing Games.

I think it will actually become a little bit self, you know, self-regenerating in a way. You come up with this idea of it’s a new issue entirely, but you can still use some of the same processes that you did in your previous assignments, to work through it, but it’s a new issue that the kids are going to get themselves interested in, and even with some like, I know when the Olympics come next year, in Maths I will be doing work with the Olympics, and that one you can do a lot in terms of measurement, history, times, predictions of what the times are going to be, everything like that, and that’s one that can be rolled every two years, so you do Commonwealth and Olympics.

The second aspect relates the future career moves of teachers. David had thought about his preferred future as an educator. He has submitted an application for enrolling in an Educational Doctorate.

Well I’m applying for a Doctor of Education, so when I, if I do get into it, and I finish the first two years of course work, the study will be, that I want to do, will be linked around that ...What I believe, is a Doctor of Education would help me to go higher in the department, whereas a PhD is probably more the academic route.

In relation to this he has already thought about a possible research direction. Yeah, it’s certainly linked up with other PD. I’m certainly keeping an eye out now more on critical numeracy, that type of stuff, which is something else I’ve watched out for, and also trying to watch out for things that, you know, I suppose place-based type of things and community issues. I was writing the research question this morning, and that was along the lines of ‘How can I use... it will be concentrating on Maths and Science in middle school, so 7s, 8s and 9s, to develop students’ socially critical numeracy skills using place-based pedagogies is where I’m looking at. That’s the way I’d like to go.

It is clear that the professional development participated in through RPIN and his post graduate work in Masters of Education has set David on a path of rigorously examining his pedagogical practices in teaching middle years mathematics and science. His contribution to the field, should he pursue his current interest in critical numeracy and place based pedagogies, could well be significant. In his opinion it is a much under-researched area of education.

**IN CONCLUSION**

This transdisciplinary approach to teaching science and mathematics has been an ambitious and complex project. Its size and the number of people involved and its aim to improve middle school pedagogy in a socially disadvantaged location all contributed to its complexity. Perhaps the greatest difficulty faced was the intensification of teacher work-load. Yet the teachers involved were amazing in their on going commitment to providing quality education for the young adolescence in their care.

The following are the key findings gleaned from the analysis of this case study which focused on the teaching of science and mathematics through a transdisciplinary approach to teaching and learning. Firstly, changes in classroom pedagogy can be made if support is available. This support must come from school structures to enable team-teaching. These interdisciplinary teams will work with the same group of students for an extended time and the teachers need support to allow team members time to co-plan.

Secondly, it was noted that considerable effort was made by all teachers involved in the project in order to develop and teach a unit of work involving classroom inquiry. In doing so they gave of their own time and resources in order to ensure the success of the project. This effort would not be sustainable on an on going basis. It was noted that each teacher repeated the innovation the following year with different classes and talked about other possibilities but in reality none of these eventuated in the three-year cycle of which this case studies was a part.

Thirdly, whilst the focus in this paper has not been about students, the key reason the teachers continued with the innovation was the improved student-engagement in the activity. The literature discussed earlier in the paper described quality educational practice and made recommendations that are pertinent to middle school
students and that involve transdisciplinary teaching that builds upon the students’ lifeworlds. This research found, that with support, teachers can cooperate to provide rigorous learning experiences in mathematics and science.

Finally, the case study found that the teachers were willing participants in the research. They gave evidence of appreciating their membership in the research teach and being affirmed and listened to. They felt that their views and contributions were valued and that their on-going relationship with the academics involved in the study provided invaluable information and support. This interaction gently challenged their assumptions and changed their classroom practice. The link between being informed through literature and educational theory and innovative classroom practice was affirmed in this project. This resulted in generating new ways of knowing and teaching and these elements have more widely communicated among other teachers. The webpage material will have even broader distribution amongst classroom teachers.

This was a grass-roots research project that will have long term benefits for the teachers involved and for their future middle school students. Quantifying the benefits of this study will be the focus of other papers.

REFERENCES


Groundwater-Smith, S., Mitchell, J., & Mockler, N. 2007 Learning in the middle years more than a transition. Thomson, South Melbourne.


EXPLORING FUTURES SCENARIO WRITING IN SCIENCE LEARNING WITH UNDERGRADUATE EDUCATION STUDENTS

David Lloyd
University of South Australia
Australia

ABSTRACT

In this paper I report on the initial phase of the evaluation of the effectiveness of futures scenario writing for developing undergraduate students' understanding of, and dispositions towards, contemporary issues associated with science. The participating students are co-researchers and have undertaken undergraduate courses in two general studies, *Astronomy and the Universe* and *Atmosphere and Climate*. The aim of future scenario writing is to provide a synthesizing mechanism for cognitive, affective, and ethical learning and calls upon higher order thinking, and in particular integrally informed futures thinking. Integral and futures thinking are not widely used explicitly in science learning in schools. The paper examines the purpose of futures scenario and their construction, and review some preliminary data.

INTRODUCTION

In this paper I report on the initial phase of a study to evaluate the effectiveness of futures scenario writing for developing undergraduate students' understanding of, and dispositions towards, science related contemporary issues. This initial phase discusses the nature and purpose of futures scenario writing in a science education context, the pedagogical approach taken and some initial data. I have argued for the importance of images of the future as an aspect of students’ prior knowledge in science learning and as a dimension of their state of well-being (Lloyd, 2000, 2001, 2006a, 2007; Lloyd & Wallace, 2004). In this study I want to evaluate the value of students writing futures scenarios for learning (cognitive, affective and ethical), and for challenging and further developing their own images of possible futures. The research questions are therefore:

- How do students go about constructing futures scenarios associated with issues based science courses?
- What learning occurs and how are students influenced in the way they think and behave when they develop futures scenarios associated with science related issues/interests?

In this first part of the study I briefly review the literature that has informed my approach to science education and futures scenario writing. Secondly, I briefly describe the process used in the two courses for constructing futures scenarios. Finally, I summarise preliminary findings on how futures scenarios were constructed, how they assisted learning and the influence the process has had on students.

OVERVIEW OF THE LITERATURE: SCIENCE EDUCATION AND SCENARIO WRITING

The aim of future scenario writing in the two general studies courses associated with this study is to provide a synthesizing mechanism for cognitive, affective, and ethical learning that calls upon higher order thinking, and in particular integrally informed futures thinking. “Integral thinking” and “futures thinking” are not widely used explicitly in science learning in schools. In this section I briefly review the literature that has informed this study: scientific education, writing futures scenarios, futures and science learning, an integral framework, and using futures scenarios.

Science education

Laszlo (1996, p. 136) believes there is a growing need for scientific knowledge related to global problems and a greater effort by human communities to solve them, and Prigogine (1986, p. 494) says “It is of great importance, particularly at present, that we reach a better harmony between the different rationalities involved in science, democracy and civilization”. The use of science learning for understanding of, and taking action in, the world is also being seen as an important aim of science education (Bowers, 2001; Hodson, 2003; Lewis & Leach, 2006; Roth & Desautels, 2002). Barton and Osborne (2002) say that science learning from this perspective “can be placed in a position (its proper position) as a tool for enacting societal change for the better” (p. 167). From this broader view of science learning, boarder crossings between student life worlds and a “western” science worldview are necessary and valued (Aikenhead & Jegede, 1999; Aikenhead, 2002), and the epistemological differences between these worlds understood (Roth & Bowen, 2002).
Hodson (2003) believes school science curriculum should include engaging in socio-political action and Fensham (2000, p. 77) points out “science in the public arena is inevitably involved with other knowledge”, and recommends four social purposes for science learning: developing personal well-being, socio-economic well-being, democratic well-being, and scientific well-being (Fensham, 2003, p. 8). He calls such an approach “citizen science”.

He also sees this more holistic approach to science curriculum as “interdisciplinary integration”, and as a necessary approach to science learning “because most real world situations involving science are multi-disciplinary” (Fensham, 2003, p. 8). A similar argument is made by those advocating a scientific literacy approach, in which students come to understand more about science and its processes, recognise its place in our culture and society, and are able to use it in their daily lives (Goodrum, Hackling & Rennie, 2001; Goodrum & Rennie, 2007; Tytler, 2007).

A variation of Fensham’s “interdisciplinary integration” is transdisciplinarity, in which not only are the disciplines called upon to address problems, but also local or place-based knowledge that values context-specific negotiation of knowledge (Klein, 2004). It “tackles complexity in science and it challenges knowledge fragmentation” (Lawrence & Despres, 2004, p. 299). In our general studies this type of approach is being developed and values the personal, social and cultural dimensions in the science learning process. I discuss our approach in more detail later.

I now look at the futures aspect of the study, and in particular futures scenarios.

**Futures Scenarios**

Miller (2007, p. 344) suggests that “[s]tories may be what make life intelligible. Certainly, humans invent and tell many kinds of stories for many different purposes”. Futures scenarios are stories with a logical plot and narrative about possible futures and their construction is a central goal of futures studies. Futures scenario writing is the least structured and most subjective of all of futures techniques. Their aim is to provide a descriptive picture of a future against which evaluations or decisions may be made. Futures scenarios are used by futurists to form perceptions of the future (the possible), to study likely alternatives (the probable) and make choices to bring about a particular future (the preferable) (Amara, 1981; Bell, 2007; Cornish, 1977; Polak, 1973; Raskin et al, 2002; Slaughter, 1999; Snoek, 2003). They lower the level of uncertainty and raise the level of knowledge in “relation to the consequences of actions, which have been taken, or are going to be taken, in the present” (Masini, 1993, p. 90). Future scenarios are part of the foresight process, which Slaughter (1995, p. 1) describes as “a human attribute that allows us to weigh up pros and cons, to evaluate different courses of action and to invest possible futures on every level with enough reality and meaning to use them as decision-making aids”. These are not utopian worlds of fiction or imaginary alternative descriptions but pictures of where we may be heading, set out graphically and directly based upon what we know about the world and what we image the world could reasonably be. They are a particular type of story, which, because of their complex and uncertain nature, are most fruitful when used in a transdisciplinary way – valuing the political, cultural, ethical, social, economic, demographical, technical/scientific, environmental and spiritual (Snoek, 2003). They are also cognisant of the idea that the future is not an empty space but full of politics and history, fear and loathing” (Inayatullah, 1999, p. 52). Polak (1973, p. 10) suggests they are central to the conscious creation of culture. They are not, and should not, be about breeding illusions and therefore, inevitably, disillusionments, nor, as they have in the past, as justifications for terrible wrongs (Wallerstein, 1998, p. 1).

Futures scenarios are particularly valuable in time of rapid change, when historically established procedures for planning prove to be inadequate (Laszlo, 2001; Raskin et al, 2002) and since about the 1970s futures scenario writing has become an important tool for planning in many governments, institutions and organizations. Ilya Prigogine (1997) goes as far as to suggest that “the future is no longer determined by the present. Mankind is at a turning point, the beginning of a new rationality in which science is no longer identified with certitude and probability with ignorance”. From such an insight, the value of scenario writing is not so much to do with prediction, but about exploration of possibilities and the development of resilience to the unexpected and novel. In the opinion of Raskin et al (2002, p. 13), “the question of the future, once a matter for dreamers and philosophers, has moved to the centre of the development and scientific agendas”. Scenario writing is central to this purpose and is a powerful tool for planning and enacting plans for liveable futures.

Futures scenario writing can also help to overcome the natural tendency for futures thinking (foresight) to be masked by “the altruistic urge to ameliorate today's suffering” (Tough, 1995, p. 27) and for us to be less concerned about tomorrow’s needs. Acquiring accurate data, taking time to reflect on the meaning of data and making appropriate plans are critical for foresight but too often these necessities are truncated for immediate needs. Even when we are conscious of the need to plan it is possible to “experience internal conflicts between today’s desirable pleasures and tomorrow’s resulting costs” (Tough, 1995, p. 27). A second pathological tendency is to have expectations for possible futures that are unfounded, over optimistic or pessimistic, and which can lead to complacency, despair, inaction or inappropriate planning. Each of these potentially life demeaning
dispositions can be overcome through developing and enacting, through practical action (praxis) (Gidley, 2002), futures scenarios built upon sound evidence.

Recent futures scenarios of note include our common future (Brundtland, 1987), Macroshift (Laszlo, 2001), Limits to Growth (Meadows, Randers & Meadows, 2004), Great Transition (Raskin et al, 2002), and planning for resilience: Scenarios, surprises, and branch points (Gallopin, 2002). In recent times futures scenario writing has been taken up by scientists. For example William Stevens (1999), Ian Lowe (2005), Tim Flannery (2005) and Barrie Pittock (2005) have all created futures scenarios to do with world systems, and in particular ecological and social sustainability.

Futures and science learning

The futures scenario assignments, which are the focus of this study, use a transdisciplinary approach. They start with a science related contemporary issue - for this study, space travel and climate change - and bring to its resolution any resources that seem appropriate, both local and disciplinary (Bruce, Lyall, Tait, & Williams, 2004; Giri, 2002; Klein, 2004; Lawrence & Despres, 2004; Masini, 1993). Venville, Wallace, Rennie, and Malone, (2002) call this integral approach a “worldly perspective” and say that “[t]his perspective acknowledges the contribution of the academic disciplines but places the disciplines within a holistic, more organic view of knowledge” (p. 71). Science learning, if it is to have the characteristics described above, needs to operate in a transdisciplinary or interdisciplinary environment, at least some of the time.

Integrating futures techniques, such as scenario writing, into science teaching and learning practices provides an opportunity “to assist students to use scientific ideas and processes to address current and emerging problems and help them to anticipate possible consequences of applying scientific ideas” (Lloyd, & Wallace, 2004, p. 164). In summary, the science learning described in this study is transdisciplinary and futures oriented, and connected to student life worlds through science associated contemporary interests and concerns.

An integral framework

I have used Ken Wilber’s (1995; 1998; 2001; 2006) integral model to inform my work (Lloyd, 2006b; 2006c) and have used the quadrants aspects of it for scenario writing with students in this study. An integral approach “advocates inner reflection and outward engagement, and the many perspectives that derive from an understanding of organic development and evolution” (Roof, 2006, p. 56) and has as its foundation “the basic moral intuition of the good, the true and the beautiful in a new holistic embrace” (Roof, 2006, p. 56). Looking at the literature that dealt with hierarchical structures, Wilber noticed that the various hierarchies fell into four major classes or quadrants. Some hierarchies referred to individuals, some to collectives, some to exterior realities, and some to interior ones, but that they all fit together seamlessly (Wilber, 2000, p. 40). This analysis formed four quadrants, the interior/individual (“I” or the “beautiful”), the interior/collective (“We” or “good”), the exterior/individual (“It” or “the true”), and the exterior/collective (“It’s” also “the true”) (Wilber, 2000; 2005). The four quadrants Wilber (1995; 2001; 2006) uses as a heuristic to organize ideas. He points out that there are important truths in both the subjective and objective approaches, and both are required for a balanced or “all-quadrant” view (Wilber, 1995).

Truth as a way of knowing can be divided into the study of individual things (“It”) and the interaction of things (“Its”), and is best investigated by science. Individual things refer to material objects that we study through the sciences. Collections of things refers here to social and natural systems e.g. ecological systems, which we study using the methods of the systems sciences (Laszlo, 1996; Von Bertalanffy, 1969). We accept ideas as being true of systems if there is functional fit – our ideas are congruent with the workings of a self-sustaining system. Interest in the future of things and systems such as global climates (Flannery, 2005; Pittock, 2005) and the fate of the universe (Croswell, 2001; Davies, 2000, 2006; Greene, 2000; Primack & Abrams, 2006) are very much the interest of science and most citizens.

The Beautiful refers to the subjective/interior thoughts of the individual characterised by “I” statements. The “I” encompasses the self and self-expression, art and aesthetics, and the beauty that is in the eye (or the “I”) of the beholder. Categories of knowing here are aesthetics, spirituality, self-identity, feelings and so on. Validation of interior thoughts of the individual is through truthfulness, sincerity, integrity and trustworthiness. We scaffold this aspect of the quadrant model by discussing aspects of the work of scientists such as Laszlo (1999; 2006), Sheldrake (1991), Suzuki and McConnell (1997) and Swimme (1996), who write about human connectivity to place and the spiritual.

The Good refers to the subjective/interior thoughts of the collective and is about human cultural worldviews and values – the ways that we—that you and I—treat each other, and whether we do so with decency, honesty, and respect - in other words, basic morality. Validation of shared thoughts occurs through justice, cultural fit, mutual understanding and rightness. Integral informed futures scenarios value the “good” and address the effects of rapid changes in societies that are concerned with industrialisation, globalisation (including increasing
levels of inequality), knowledge acceleration and the rise of the information society, growing cultural diversity, and various environmental changes (Laszlo, 2003; Nussbaum, 2006; Singer, 2002; Singer & Gregg, 2004; Wilber, 2000). We workshop both the politics and ethics associated with space travel and global warming using some of the material already indicated in this section, plus other such as Hamilton (2007) and web-based media materials.

Learning, from an integral perspective, is more than a study of the external world of things and systems but includes the associated aesthetic/spiritual and social/cultural aspects. Science is an important part of this integral picture where its contributes to the understanding of the external world of things and systems but is often imbedded in an approach to learning that is viewed from a broader perspective than just the technical interest (Bowers, 2001, 2006; Hodson, 2003; Lloyd, 2003, 2006a; 2006b; 2006c; Lloyd & Wallace, 2004). This view is evident in the definitions of scientific literacy and the approaches suggested by Fensham (2000; 2003) and Hodson (2003).

Futures scenarios that are integrally informed consider all that is understood about Kosmos (Laszlo, 2006; Wilber, 1995, 2000) in the creation and enacted process (Slaughter, 2004). From my analysis of the processes and products of scenario writing I have come to the view that they are often integrally informed, or at least have many elements of an integral view, even though their author may not use this term. An integrally informed scenario is spiritual, scientific, ethical and political (Slaughter, 2004).

I have taken advantage of this integral schema to inform futures scenario writing. A fuller description of an integral model as I have applied it to the general study can be found in Lloyd (2006b; 2006c).

Using future scenarios

I have used futures scenarios in the general studies courses primarily for two reasons; firstly, as a mechanism for students to deeply process course material; and secondly, to develop their disposition towards, and facility in the use of futures thinking (Slaughter, 1995) - as I have outlined above. Educationally futures scenarios have the purpose of catching students’ attention and their imagination by highlighting different aspects of possible futures (Hicks, 2002, p.47) and an empowering way to synthesis understandings of how the world is and could be by drawing on understandings of the physical, social, cultural, affective (Hicks, 2002; Hicks & Slaughter, 1998; Hutchinson, 1996; Jucker, 2002; Paige, Lloyd, & Chartres, 2008; Sterling, 2002). In this study student use their understandings of the science of global warming and space travel (“it” and “its”), the worldview foundations and ethics associated with these two areas (“we”), and their own personal spiritual and self-expression (“I”) to build futures stories of the world in 20 to 50 years.

In the next section I describe aspects of the process used to develop futures scenarios.

FUTURES SCENARIO WRITING: THE PROCESS

Futures scenario studies usually produce a range of stories built upon a combination of possible events both natural and humanly engineered. However, it is usual to reduce the complexity of reality by developing a limited number of polar types that sensitise users to the strategic choices to be confronted. They are likely to range from utopic to dystopic in nature when built around the extremes of key variable. The first task for the scenario writer is to decide on the type of scenarios to be constructed and then to construct them with the best understandings of how the world, including humans, work. Scenarios are of little value unless enacted, and so the final process is to bring the desired futures scenario to life through strategic plans and actions. In the application of futures scenarios in this study, for pragmatic reasons such as available instruction time, students build only one scenario.

There are many articles in the literature that discuss how professional futurists go about the construction of futures scenarios (Borjeson, Hojer, Dreborg, Ekvall, & Finnevenden, 2006; Cautreels, 2003; Hilton, 2003; Inayatullah, 1993; Savitsky, 2003; Snoek, 2003; Tydeman, 1987; van’t Klooster & van Asselt, 2006). These generally provide a level of sophistication that is confusing or too complex, rather than helpful, for the beginner scenario writer. Approaches suggested by educators are friendlier to the novice (Hicks, 2002; Slaughter, 1995b; Whaley, 1991). Experience over the last two years while developing this aspect of the courses has shown that too much information about scenario creation is counter productive. Reil Miller’s (2007) second approach (GBU) is the one I currently use. She explains,

The first (approach), springing directly from the predictive tradition, takes an initial starting point, for instance population or economic output, and then develops scenarios on the basis of a range of growth rates—low, medium and high. This method can be called the baby-bear, momma-bear and papa-bear approach (Bear for short). The second technique focuses more on preferences and expectations in order to sketch scenarios that capture the stories of the futures that people consider to be: the most desirable, the least desirable and the muddling through version that mixes a bit of good and a bit of bad (which also usually happens to be the one people consider most likely or realistic). This method can be dubbed ‘the good, the bad and the ugly’ approach (GBU for short).

351
The process I provide for students for developing the confidence and skill in scenario writing is to workshop a scenario prepared for the courses using the framework described below and then ask students to read a variety of provided short futures scenarios (Conlan, 1995; Fisher, 1989; Gahagan, 1991; Sale, 1995) and deconstruct one of these using the framework used in the workshop. They are provided with references to more extensively constructed scenarios including Eckersley (1999), Laszlo (2001) and Raskin et al (2002).

Writing Futures Scenarios

The description of scenario development provided here is by necessity very brief. While the development process for writing futures scenarios is linear in nature, the actual five step process is likely not to be. While all steps are necessary, it is very likely that there will be backward and forward movement through the steps. For example, the decision on genre, part of Step 4, might be made first rather, or students may need to gather, quite late in the writing process, more information that was either not dealt with during the course or not anticipated as needed. Although the scenario assignment is introduced to students at the beginning of the course (we have one 3 hour workshop per week for 13 weeks), and students are asked to start the process of collecting background resources, particularly from the course readings and course workshops, student do not start on the detailed planning until mid-way through the course. The first half of the courses is primarily about understanding the science of astronomy or climate, although some aspects of the social and cultural impacts/interests do come in.

The first formal step (Step 1) to scenario writing is to identify what the scenario is about and its purpose - the scenario question. Students are provided with the key issue (space flight for the astronomy course and climate change for the atmosphere course); more specific aspects are left for the students to decide upon. I do ask the students to use a back casting approach (Miller’s GBU) and a time span of 20 to 50 years rather than a few years or generations. This approach restricts the extent of the scaffolding needed to support students, for whom scenario writing is for most a novel genre.

In the second step (Step 2) students collaboratively search for the variables describing the system. This step includes identifying the policies and practices already in place or being developed that impact on the identified issues, and trends and the assumptions and hypotheses that underpin them, and then interrogate them (Kleiner, 1999). The quadrants tool, (the science of things and natural systems including humans; personal well-being; cultural/world-view considerations) is used here. Because Step 2 will likely throw up a multitude of variables, it is necessary to select the most important variables of change. So, the third step (Step 3) concerns deciding on the variables that are the key drivers and then planning the scenario (Miller, 2007). Having done this groundwork in the first three steps, it is now time to decide on the possibilities and form of the scenario - Step 4. With respect to possibilities, do I choose a scenario that is breakthrough (utopian or eutopian) or breakdown (dystopian) (Laszlo, 2001)? Will it be a story centred around “more of the same”, “technological fix”, “edge of disaster”, or “sustainable development” (Hicks, 2002, p. 47); or perhaps a story about a conventional world, or barbarised world, or a story of a world in transition, or will it be “just muddling through” (Raskin et al 2002)? The genre for the scenario is also decided here; a letter, a journal, a news paper article, an academic paper, a children’s story, a short story, a chronic, a business report …? The final step, Step 5, is to write the scenario and bring it to life. The scenarios can be brought to life by visualising it in a particular context and using an appropriate genre to tell the story. While usually the scenarios is used to generate policy changes and action plans, in our courses we present them to other members of the class as an act of celebration and the opportunity to discuss the scenario with others using a “positive, negative and interesting” format to identify likely outcomes if the scenario is brought to fruition. We also use this opportunity to provide formative assessment feedback before final submission.

It is hoped that at the personal level the scenarios are useful in helping individuals make decisions about their own live styles and commitments to future generations – this is Step 6, moving from the scenario to strategic transformations to help create better personal, social and world futures.

CONTEXT AND PRELIMINARY DATA

The study is being undertaken with undergraduate students taking two general studies courses, Astronomy and the Universe and Atmosphere and Climate, in which the final assignment is the writing of a futures scenario on space futures and climate change. The students, in the main, are undertaking a four-year Bachelor of Education specialising in primary and middle schooling. I am the coordinator and main lecturer for the course. I invite other lecturers and community educators to deliver specialist aspects. They are not involved in the presentation of the futures scenario material or the assessment process.

---

1 While students are undertaking this scenario construction for educational purposes (deep processing of scientific concepts, application of science to lifeworld situations, developing disposition to foresight, developing skills in scenario writing), futurists would use them for contingency planning, policy development, simulation training, team building, optimisation testing or strategic imagining.
Due to word restrictions, I have not been able to included examples of the evidence discussed here. However, a range of methods are being used to collect evidence, including Course Evaluation Instrument (CEI)\(^2\), Student Evaluation of Teaching (SET), students’ futures scenario assignments, reflective writing, focus groups and interviews. The study sample is the 2007 (50 students) and 2008 course (fifty students) participants. The preliminary data set collected for 2007 includes CEI and SET data which is about the class and the way it is managed; students’ scenarios assignments, written and taped responses from 17 students working in 4 groups from the Semester 2 class on the their thoughts on scenario writing, and two detailed reflective responses. I have adopted at this stage the following framework to talk about this evaluation material:

Satisfaction with the course content and pedagogy (mainly from CEI and SET data), which provides a measure of the quality of the course in which the futures scenario assignments are a part.

Strategies for developing scenarios. This section will also look at the use of, and responses to, the integral framework (quadrant model) as an organising framework (mainly student thoughts on scenario writing discussion and written responses and analysis, and student thoughts on scenario writing discussion and written responses). This contributes to answering the first research question.

Value of the scenario method for deep learning and personal development (CEI and SET data, student thoughts on scenario writing revealed in discussion and written responses and the two detailed reflective responses). This section contributes to answering the second research question.

Ways the scenario writing has changed students’ own ways of thinking and behaving (Student written responses and interviews). This aspect contributes to answering the second research question. Evidence as to whether or not students enact the scenario they construct will require a more extensive longitudinal study.

**Satisfaction with the courses and pedagogy**

Almost all respondents (90%) to the CEIs and SETs (averaging around just over 50% of the class) indicate satisfaction with the overall quality of the course (I enjoyed the whole course and would recommend the whole course to others; great course would recommend it to others) and all agreed or strongly agreed that the course developed their understanding of concepts and principles. A similarly high proportion of students found the pedagogy appropriate and empowering for their own learning and as preparation for their future careers as teachers. The data indicates high levels of satisfaction with the course content and pedagogy.

**Strategies for developing scenarios**

Although strategies for tackling futures scenario writing is workshopped and many examples of futures scenarios are provided, I am never-the-less interested in seeing how students go about developing them. The teaching material used in workshops has been adapted in the main from the work of professional futurists. There are likely to be novel and more appropriate strategies developed by students. The student data I have used thus far is rather superficial in nature and insights draw from them tentative. Far more in-depth interviewing is needed to evaluate this area. The analysis given here is from 17 students’ thoughts on scenario writing revealed in discussion and written responses.

**General strategies**

To prepare for futures scenario writing students collectively used a wide range of resources including newspaper article, books, the Internet, DVD/movies, workshop material, and example scenarios. It seems that many took note of the initial workshop suggestion that they keep records of their interaction with the readings and group discussions as material to draw upon. They also used a range of strategies for processing their data and building their scenario (mind or concept mapping, brainstorming, futures wheel, drafting, linking of readings to key ideas, making comparisons).

The most common primary organising idea was the genre. Genre types included newspaper articles, personal journals, letters to a friend or relative, briefing for a court case, and reports. Other students “… just looked back through the readings and looked at the sample scenario to give…some ideas”. Many students used as their initiating move the audience they were writing to”. One student “concentrated on what effect me and what I find interesting”.

**Use of, and responses to, the integral framework**

A number of students indicated in their written and verbal responses that they were not confident using the quadrants approach. The observation that “I don't think I used it to the best of my ability because I need more

---

2 CEIs and SETs are online evaluation instruments completed voluntarily and anomalously by students at the end of the course. They have the opportunity to complete a 10 question Likert Scale questionnaire and give free response to questions about the quality of the course/teaching and subjected changes/improvements.
practice on it” came up a number of times. Student did not articulate the nature of their difficulties, but it may be because they had not as yet been able to differentiate in enough detail the nature of each quadrant and differences between them – a challenge in epistemology. Students, who did find the quadrants framework useful, used it as a framework to build the big picture and give a “balanced argument/discussion, not leaving anyone out” and to “make sure I covered everything”. It “helped … put … ideas on paper”. The quadrants framework was seen as a “very useful tool in providing a big picture for future scenario writing”. Other students used the framework as an analysis tool.

**Writing to the quadrants**

A closer analysis of students’ futures scenarios is needed to make detailed comment on how the quadrants have been addressed, but an initial reading of the data suggests that students are more comfortable and confident writing about social (“its”) and cultural (“we”) aspects than about the personal (self) and spiritual (“I”). Students’ confidence to include the science (“it”) and (“its”) is mixed, and varies in quality from clear understandings of the science and its use to superficial, and in a few cases identifies misconceptions.

**Value of the scenario method for deep learning and personal development**

There were a number of responses in the CEIs and SETs that indicate that the futures scenario assignment was useful for learning and enjoyed. It seems that at least some students found the futures scenario activity a synthesising or integrating one. When responding to the SET question, “What were the best aspects of this staff member's teaching?” one student responded, “His use of scenario writing allows students to express all their knowledge rather than just specific and limiting questions”. Other responses from this data indicate that for a number of students, the futures scenario activity was life confirming and life changing. Two other students when answering the question, “What were the most valuable aspects of the futures scenario writing?” respectively wrote,

“Having to think about what the world will be like in 30 yrs time and what we may have already done or are now doing to cause this type of future. The idea that there is hope and we can all do our bit.”

“I guess looking at current events from a future perspective. Using the theory to think about what the future may look like. The fact that it made you think of the future. The opportunity to try and look into the future and see what may be.”

An analysis of students written and verbal responses identifies at least three ways in which the activity enhanced learning: conceptual learning, skills in evaluation and reflection, and foresight.

**4. Ways the scenario writing has changed ways of behaving**

The initial data revealed at least three ways students claim to have been changed. Firstly, they believe they are better informed. Secondly, students say they have become proactive to environmental issues. A few students want to become politically more active. The final category is to do with becoming a teacher and community leader. The given question was: “As a future educator I can use this to help my class in understanding how climate change is working and how it's affecting our environment and also is going to help challenge my behaviour in everyday life as well”.

**CONCLUDING COMMENTS**

I have described in this paper the first phase in the evaluation of futures scenario writing as an integrating and empowering approach to learning science. Futures scenario writing, as pointed out by Rogers (1998, p. 205), is a process that involves not only the mind, but also the heart and the soul, and when integrally informed is learning about matter (physiosphere), life (biosphere), mind (noosphere), soul and spirit (Wilber, 1995, 2006). The approach to science learning, of which the futures scenario writing task is a part, is strongly connected to students’ life worlds and consistent with the attributes of scientific literacy (Goodrum & Rennie, 2007), citizen science (Fensham, 2003), science for an alternative future (Hodson, 2003) and science education as/for sociopolitical action (Roth & Désautels, 2002).

Preliminary data indicated that students are satisfied with courses in which the futures scenario assessment task is embedded, that students are developing useful strategies for developing futures scenarios, that futures scenarios support deep learning and personal development, and are life informing and transforming.

**REFERENCES**


Abstract

This paper describes a study designed to examine how students in years 9 and 10 at six high schools located in southwest Sydney go about solving geometry problems; how the classroom learning environment is influenced and influences this experience, and how the experience affects students’ attitudes towards geometry. Participants completed the What Is Happening in this Class (WIHIC) questionnaire, and also completed tests involving the solving of basic geometrical problems. The results of the analysis of the quantitative data gained from pretest and posttest, and of qualitative data gathered from classroom observations and interviews, were used to assess the learning environment and to determine how to differentiate the associations between students’ abilities to solve geometry problems, their attitudes, and the influence of the learning environment. The results of this research using the WIHIC instrument and specially constructed tests on geometry revealed statistically significant results regarding students’ perceptions of their geometry classroom learning environment and their attitudes towards geometry.

Introduction

In learning geometry, students are encouraged by teachers to communicate their understanding of geometry concepts and expressions through engaging in geometrical activities and through making meaning of language/symbolic systems and diagrams, concepts and problem solving over time. It is important for students’ ideas to be heard and critiqued in the geometry classroom, for the teacher to provide support for their learning, and for students to share their understanding of the topic.

By the end of primary school students have spent at least 7000 hours of their life in classrooms and by the end of secondary school, they have attended school for approximately 15,000 hours. It is a huge amount of time; therefore students’ reactions to their teaching and learning experiences and the quality of classroom life are very important to the achievement of stated goals (Fraser, 2001). Most classroom environment research has involved students in Western countries such as the USA (Walberg, 1979), the Netherlands (Wubbels & Levy, 1998) and Australia (Fraser, 1990). Learning environment research involves a range of observational and interpretive methods including questionnaires which assess students’ and teachers’ perceptions of factors. Tobin & Fraser (1998) point out that “the past research has used learning environment questionnaires in curriculum evaluation (Fraser, 1979), in studies of differences between students’ and teachers’ perceptions of the same classroom (Fisher & Fraser, 1983) and teachers’ practical attempts to improve classroom learning environments (Thorp, Burden & Fraser, 1994)” (p. 624). Few of the above studies have involved the topic of geometry, and this situation provided the impetus to examine how the classroom environment impacts and is impacted upon, by this subject.

Aims of the Study

Objective

The purpose of this study was to investigate the associations between students’ abilities to solve geometry problems, their attitudes and learning environments relating to teaching and learning interaction. These objectives can be expressed as follows, to:

1. Validate an instrument based on the WIHIC questionnaire in order to assess students’ perceptions of their geometry classroom learning environment.
2. Examine associations between students’ perceptions of their geometry classroom learning environment and their achievement in geometry.
3. Investigate the influence of gender on students’ perceptions of their geometry classroom learning environment.
4. Investigate the influence of the geometry classroom learning environment on students’ attitudes towards geometry.

To address these objectives, the following Research Questions were formulated:
Research questions:
1. Can a reliable and valid instrument be developed to assist in assessing students’ perceptions of their geometry classroom learning environment?
2. Do students’ perceptions of their geometry classroom learning environment influence their achievement in geometry tests?
3. Does students’ gender influence their perceptions of their geometry classroom learning environment?
4. What is the influence of the classroom instruction on students’ achievement in geometry tests?

Method

The sample was selected randomly from six high schools in southwest Sydney in which students were from low socio-economic status (SES) backgrounds. The participants were 468 Years 9 and 10 students in 17 classes and their mathematics teachers together with mathematics head teachers in nominated schools. Six schools were included in this study, some schools having two Year 9 and two Year 10 classes of around 28-34 students in each class. Careful selection of the six schools ensured that the criteria of the different culture and the low socio-economic status background for selection were maintained.

Participants for interviews and observation were randomly selected from 17 classes. There were 24 students consisting of a group of three students in Year 9 class and another group of three in Year 10 class, and four teachers consisting of one teacher (one teacher either from Year 9 or Year 10) in each school to be interviewed. Two classes (from Years 9 and 10) in each school were observed.

A modified learning environment questionnaire for students, one that combined the WIHIC with the My Classroom Inventory (MCI) and consisting of 66 items in nine scales was administrated to the participants. It measured student perceptions on the nine scales of Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity from the WIHIC, and Difficulty and Satisfaction from the MCI. Each scale from the WIHIC contained eight items while the two scales from the MCI contained five items. The items in each scale were scored 1, 2, 3, 4 and 5 respectively and for responses “almost never”, “seldom”, “sometimes”, “often”, and “almost always”. In addition, a modified learning environment questionnaire for teachers that also combined the WIHIC with the MCI consisted of 54 items. It measured teacher perceptions on the nine scales of Student Cohesiveness and Satisfaction containing five items in each scale; Teacher Support, Equity and Investigation containing six items in each scale; Task Orientation and Cooperation containing 7 items in each scale; Involvement containing eight items; and Difficulty containing four items. Each scale contained a different arrangement of items. The new version of the WIHIC consisted of 9 dimensions and was adapted from the original by Fraser, McRobbie, and Fisher (Aldridge, Fraser & Huang, 1999, p. 49).

Years 9 and 10 students experiences which basic geometry concepts from previous learning in the mathematics class were taken into account in completing the What Is Happening in this Classroom (WIHIC) instrument and the Test on Basic Geometry Knowledge (TOBGeK) questions.

The primary data collection phase involved the initial WIHIC questionnaire (pre-test and post-test) completed by participants. The secondary phase consisted of the completion of a test in solving geometrical problems. In this phase, data concerning students’ knowledge and understanding of various basic geometrical concepts was collected. The third phase involved practising worked examples, exploratory interviews and observations directed at understanding the frames of reference and spans of attention of respondents using the WIHIC questionnaire and classroom observation list. The fourth phase consisted of the students and teachers’ completion of the WIHIC questionnaire as a post test. Observation was conducted during regular class time.

The qualitative data was collected from interviews with students and teachers and observations of mathematics classrooms. The qualitative data collections demonstrate students’ views of their tasks and their attitudes towards geometry. Three significant tasks concerning classrooms learning environments were carried out:

1. The validation of a WIHIC instrument to enhance the significance in the study of geometry classrooms environments.
2. The relationship between students’ attitudes toward learning basic geometry knowledge (adjacent, alternate, corresponding, co-interior, complementary, supplementary and vertically opposite angles) and the links between the results from their tests and facets of classroom learning environment were examined.
3. The associations between perceptions of learning environments and students’ abilities in solving geometry problems and their attitudes were also observed.
The Classroom Setting

In each classroom, seating was divided into three/four rows and three/four columns consisted of 28 to 32 students. There was a lack of materials’ and teaching resources’ facilities for use during the geometry lesson, for example geometry class sets (rulers, compass, protractor, and a set of angles), were all unavailable and only mathematics textbooks were available. On the walls around the classroom, there were some posters relating to geometry, but these were few and far between.

Lesson began with revision to enforce understanding the geometry concepts taught earlier. Teachers controlled one third of the lesson time in any one period, spent approximately five to ten minutes for house-keeping and students spent the remaining time working independently. The teaching approach invariably utilised a traditional teaching method: blackboard and chalk to write and explain concepts to students. The period time for teaching was generally 45 minutes although some were of 30 minutes duration.

Teacher planning was very good in the design of the lessons and took into accounts geometrical tasks and interactions coherent with geometry, and they reflected sound planning in this topic. The teacher’s questioning strategies enhanced the students’ understanding to solve problems and all students were interacting with the teacher cooperatively and were encouraged to participate and to ask questions. In general, students spent 30% of the whole class listening to the teacher, 30% on small group work and 40% an individual learning time during geometry lessons in the classroom.

Results

Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with other scales)

In this study, the internal consistency reliability (Cronbach Alpha) was used to assess each item in a scale of the WIHIC instrument. The results for each of the 9 scales for the WIHIC in the pretest and posttest forms are shown in Table 1 following.

Table 1 Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation with other scales) for WIHIC scales.

<table>
<thead>
<tr>
<th>WIHIC Scales</th>
<th>No. of Items</th>
<th>Alpha Reliability</th>
<th>Discriminant Validity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pretest</td>
<td>posttest</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>8</td>
<td>0.87</td>
<td>0.89</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>8</td>
<td>0.91</td>
<td>0.92</td>
</tr>
<tr>
<td>Involvement</td>
<td>8</td>
<td>0.88</td>
<td>0.92</td>
</tr>
<tr>
<td>Investigation</td>
<td>8</td>
<td>0.92</td>
<td>0.94</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>8</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>Cooperation</td>
<td>8</td>
<td>0.91</td>
<td>0.92</td>
</tr>
<tr>
<td>Equity</td>
<td>8</td>
<td>0.94</td>
<td>0.95</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>5</td>
<td>0.36</td>
<td>0.55</td>
</tr>
<tr>
<td>Difficulty</td>
<td>5</td>
<td>0.39</td>
<td>0.48</td>
</tr>
</tbody>
</table>

The scale reliability ranges from 0.36 to 0.94 for pretest and from 0.48 to 0.95 for posttest. Discriminant Validity (Mean Correlation with other scales) ranges from 0.10 to 0.45 for pretest and from 0.13 to 0.50 for posttest. The highest alpha reliability is 0.94 for pretest and 0.95 for posttest in Equity scale and the lowest is 0.87 for pretest and 0.89 for posttest in Student Cohesiveness. However, seven out of nine scales of the WIHIC showed high alpha reliability which indicates that this instrument distinguishes significantly between students’ perceptions.
(achievement and attitudes) in the classroom learning environment toward geometry.

Table 2 and Figure 3 shows students’ perceptions of learning geometry are significant amongst the four scales of Task Orientation, Student Cohesiveness and Cooperation. The mean scores are higher than other scales, which are 4.08 for Task Orientation, 4.03 for Student Cohesiveness, 3.78 for Cooperation and 3.76 for Equity in the posttest. The perceptions of learning environments show a close range of the standard deviation less than 1(from 0.62 to 0.99). When the mean scores of Difficulty scales are down a little bit from 2.96 for the pretest to 2.97 for the posttest, the mean scores of Satisfaction are increased from 3.12 for pretest to 3.46 for posttest.

![Figure 1](image1.jpg)

Internal Consistency Reliability of pretest& posttest

![Figure 2](image2.jpg)

Discriminant Validity of pretest and posttest

Table 2 Mean scores of WIHIC (Pretest & Posttest), and values of Cohen’s d

<table>
<thead>
<tr>
<th>Scales</th>
<th>Means</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pretest</td>
<td>posttest</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>3.71</td>
<td>4.03</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>3.10</td>
<td>3.44</td>
</tr>
<tr>
<td>Involvement</td>
<td>2.94</td>
<td>3.29</td>
</tr>
<tr>
<td>Investigation</td>
<td>2.94</td>
<td>3.25</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>3.92</td>
<td>4.08</td>
</tr>
<tr>
<td>Cooperation</td>
<td>3.48</td>
<td>3.78</td>
</tr>
<tr>
<td>Equity</td>
<td>3.53</td>
<td>3.76</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>3.12</td>
<td>3.46</td>
</tr>
<tr>
<td>Difficulty</td>
<td>2.96</td>
<td>2.97</td>
</tr>
</tbody>
</table>

p< 0.01**, N=468 from 17 classes
Table 3 below shows that females have a mean score higher than males in their geometry classroom learning environment in mostly all of the WIHIC scales, except involvement, investigation and satisfaction. The “Difficulty” scale of the WIHIC shows means scores of males and females are shared, for pretest males are higher than females, in contrast females are higher than for posttest, which indicates that boys have difficulties in the beginning of the year and ease off at the end of their schooling year. However, males are significantly more successful in both pretest and posttest of the WIHIC survey.

**Associations between learning Geometry and Satisfaction**

Associations between geometry classroom learning environments used the WIHIC scales and students’ attitudes towards solving geometry problems were measured by simple correlation (r), multiple correlations (R) and regression (β) analyses to verify the outcomes of both geometry test and satisfaction. Table 4 shows the results of the simple correlation analysis indicated that seven scales in WIHIC were significantly correlated with students’ attitudes toward geometry classroom (p<0.01). These outcomes of learning environment also revealed that associations between learning geometry ranged from 0.24 to 0.41 for Satisfaction and ranged from – 0.04 to 0.06 for geometry test scores were positively success in this research.

**Table 3 - Mean of WIHIC by Gender differences for Pretest & Posttest**

<table>
<thead>
<tr>
<th>Scales</th>
<th>Gender</th>
<th>Means</th>
<th>SD</th>
<th>Mean-Differences</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>pretest</td>
<td>posttest</td>
<td>pretest</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>M</td>
<td>3.66</td>
<td>3.97</td>
<td>0.77</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.76</td>
<td>4.10</td>
<td>0.71</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>M</td>
<td>3.09</td>
<td>3.40</td>
<td>0.97</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.12</td>
<td>3.47</td>
<td>0.88</td>
</tr>
<tr>
<td>Involvement</td>
<td>M</td>
<td>2.97</td>
<td>3.35</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2.89</td>
<td>3.23</td>
<td>0.74</td>
</tr>
<tr>
<td>Investigation</td>
<td>M</td>
<td>2.97</td>
<td>3.30</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2.90</td>
<td>3.20</td>
<td>0.81</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>M</td>
<td>3.91</td>
<td>4.05</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.94</td>
<td>4.10</td>
<td>0.74</td>
</tr>
<tr>
<td>Cooperation</td>
<td>M</td>
<td>3.45</td>
<td>3.71</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.52</td>
<td>3.86</td>
<td>0.80</td>
</tr>
<tr>
<td>Equity</td>
<td>M</td>
<td>3.46</td>
<td>3.66</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.61</td>
<td>3.88</td>
<td>0.91</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>M</td>
<td>3.13</td>
<td>3.48</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>3.10</td>
<td>3.44</td>
<td>0.59</td>
</tr>
<tr>
<td>Difficulty</td>
<td>M</td>
<td>3.03</td>
<td>2.95</td>
<td>0.63</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>2.89</td>
<td>3.00</td>
<td>0.52</td>
</tr>
</tbody>
</table>

N = 468, Male =245, Female = 223 from 17 classes
Twenty five percent \( (R^2 = 0.25) \) of the variance is explained by satisfaction and is statistically significant. The multiple regressions \( R = 0.50 \) indicate that students’ attitudes toward the learning environment are statistically significant \( (p<0.01) \). The table also indicates that 2% \( (R^2 = 0.02) \) of the variance in students learning geometry is quite understandable of their successful achievement outcomes in their test of the TOBGeK. The multiple regression \( R = 0.15 \) indicates that students’ perceptions of their abilities in solving geometry problems toward learning environment are positive and statistically significant. The correlation \( r = 0.09 \) of the Investigation scale also shows a statistically significant contribution to explaining students’ investigation.

### Table 4

Outcomes-Learning Environment Associations between learning Geometry and Satisfaction measured by Simple Correlation \( (r) \), Multiple Correlation \( (R) \) and Standardised Regression Coefficient \( (\beta) \) on the WIHIC for two analysed scales

<table>
<thead>
<tr>
<th>Learning Environment Scales</th>
<th>Satisfaction</th>
<th>Geometry posttest scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( r )</td>
<td>( \beta )</td>
</tr>
<tr>
<td>Student Cohesiveness</td>
<td>0.24**</td>
<td>0.09*</td>
</tr>
<tr>
<td>Teacher Support</td>
<td>0.41**</td>
<td>0.09</td>
</tr>
<tr>
<td>Involvement</td>
<td>0.41**</td>
<td>0.16</td>
</tr>
<tr>
<td>Investigation</td>
<td>0.38**</td>
<td>0.09</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>0.33**</td>
<td>0.06</td>
</tr>
<tr>
<td>Cooperation</td>
<td>0.38**</td>
<td>0.14</td>
</tr>
<tr>
<td>Equity</td>
<td>0.41**</td>
<td>0.15</td>
</tr>
<tr>
<td>Multiple Correlation</td>
<td>( R = 0.50** )</td>
<td>( R = 0.15** )</td>
</tr>
</tbody>
</table>

\*\*p<0.01  \*p<0.05

### Discussion

A multi-method approach was used to investigate the associations between students’ abilities to solve geometry problems and the learning environment. Quantitative data collection was used in the What Is Happening in this Class? (WIHIC) questionnaire consisting of 66 items of 9 scales and the test on basic geometry knowledge (TOBGeK) consisting of 33 questions in the seven diagrams supported the validity and reliability of the nine scales. Nearly all of the scales had similar results in the a priori nine-factor structure of the WIHIC. The internal Cronbach (alpha reliability) showed significantly on both analyses and ability to distinguish between classroom learning environment and students outcomes from the test on basic geometry knowledge, entailed high scores close to a perfect of 1 (i.e. 0.95 in Equity, 0.94 in Investigation, and 0.92 in Teacher Support, Involvement and Cooperation for posttest). The findings from the pretest and posttest in the WIHIC and in the test on basic geometry knowledge indicated that students improved in their geometry scores. The comparison of scale means between pretest and posttest of the TOBGeK resulted in 25.48 for pretest and 32.49 for posttest.

### Conclusion

The results indicate that the validity and reliability of the WIHIC instruments are satisfactory for use with junior high school geometry classes in southwest Sydney. The alpha reliability and the Discriminant Validity (Mean Correlation with other scales) show that student’s perceptions toward learning geometry improved after experiencing intervention and other teachers’ strategies used in the geometry classroom. The results of the factor analysis support the autonomy of factor scores on the nine scales in WIHIC instrument. However, students’ attitudes increased on the posttest for nearly all scales, except in the Difficulty scale which drops for the posttest. This means that students were successful in learning geometry.
Students moderated the seven different types of diagrams (Adjacent angles, Alternate angles, Co-interior angles, Vertically Opposites angles, Supplementary angles, Complementary angles and Corresponding angles) by adapting the Van Hiele (1986)’s geometrical thought in the level I. There were three parts to solving basic geometry knowledge in the test (Part A involved matching angles with their names; Part B involved basic geometrical concepts, and Part C involved answering questions and giving reasons). The results from this test showed that Part A involving matching angles with their names was the easiest part; Part B involved basic geometrical concepts which entailed calculations. Part C involved answering questions and giving reasons which students found very hard to answer.

The results from this study have shown significant satisfaction among students in geometry classrooms. The teaching and learning at six government schools in Southwest Sydney shows a lot of talent and useful learning experiences for students who have a great opportunity to improve their ability and mathematical skills in geometry. The findings from the modified WIHIC and the TOBGeK instruments that used a combination of quantitative and qualitative methods also display satisfactory validity, internal consistency reliability and discriminant validity, and they differentiate between the perceptions of students in different classrooms towards learning geometry.

Teaching geometry needs to look at more students’ activities and the demonstration of hand-on activities using basic diagrams, mathematical terminologies and further ideas of making geometry more satisfactory for students than under current teaching and learning programs in New South Wales. More resources relating to geometry should be employed in mathematics classrooms besides textbook exercises, and materials need to be available for student use (i.e. wall posters, flash cards, geometry sets, and more work sample including homework). Simple geometry tools give students a familiar and easier way to start as learn to cope with new concepts and diagrams.

References


Fraser, B. J. (2001). Twenty thousand hours: Editor’s introduction, Learning Environments Research; An international Journal, 4, 1-5.


Rickards, A. W. J (1998). The relationship of teacher-student interpersonal behaviour with student sex, cultural backgrounds and student outcomes. *SMEC at Curtin University of Technology, adt-WCU20020701.163045*


Tadich, B. J. (2002). “Significant factors influencing the teaching and learning of Mathematics among Year 9 students, Curtin University of Technology.


THE IMPACT OF REMOTE LABORATORIES IN IMPROVING BLENDED LEARNING IN THE SCIENCE AND TECHNOLOGY ARENA

Steve Mackay and Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

The purpose of this paper is to provide an overview of a portion of our research which is an investigation into the impact remote laboratories have on a blended learning environment. This is especially in improving the reaction and achievement of learners compared to that of only the traditional classroom or in the use of e-learning. There has been a significant increase in the level of remote or distance learning using the Internet, often referred to as e-learning or online education. E-learning is often combined with classroom instruction and on-the-job training and is referred to as blended learning. One of the gaps in current research is the examination of the impact of remote science and technology laboratories on the blended learning experience. Researchers have noted that many distance learning students have found that traditional laboratory experiments were not an option due to geographical separation and cost. They suggested offering some form of virtual or remote laboratory environment for distance learning students such as a virtual lab which comprised simulation software running on a host machine or alternatively a remote laboratory using real equipment situated at a significant distance from the learner. This research examines the impact that remote laboratories have on the blended learning experience and makes suggestions for a wider application of this technology. The paper concludes with a discussion of the proposed research by the authors to investigate the impact of blended learning on corporate industrial automation training with a real demonstration between participants in Thailand and a remote laboratory situated in Perth, Australia.

INTRODUCTION

Over the past decade, there has been a proliferation of remote or distance learning using the internet (often referred to as e-learning or online education) in the technology and industrial automation education areas (E. Allen & Seaman, 2006; Bersin, 2004; Bonk & Graham, 2006; Ma & Nickerson, 2006; Rossett, 2001). Typical approaches for e-learning are web-based (asynchronous) and streaming of video (synchronous) over the internet (Rossett, 2001). The two forms of learning are illustrated in Figures 1 and 2.
Some years ago, Kazmer and Haythornthwaite (2004) quoted from Pew Internet and American Life Project (*The Internet and education*, 2001) that “On any one day, at least one million people in the U.S. are online taking a course” (p. 7). Claims have been made by early pioneers such as Whalen (2000) on the improved learning achieved and cost effectiveness and by extension, return on investment (ROI) of this form of training compared to that of traditional classroom based training. Zhang, Zhao, Zhou, and Nunamaker (2004) indicated that learning using information technologies was rapidly growing due to the
increasing demands for quicker time to gain competency in a subject and the issues of globalisation and accelerating competition. Kanyongo (2005) referred to Smith (2001) who listed the benefits of e-learning as being “accessibility, flexibility, participation, absence of labelling, written communication experience and experience with technology” (p. 1). On the other hand, Smith (2001) listed the problems for e-learning being that of “team building, security of online examinations, absence of oral presentation opportunities and technical problems” (p. 1). Brown and Lahoud (2005) noted the remarks of Moore and Kearsley (1996) that courses delivered at a distance can be as good as that of traditional classroom instruction.

There has been some conjecture about the best blend between online education and traditional classroom instruction (Banks, 2004). Blended learning (Bersin, 2004; Mackay & Stockport, 2006) is a combination of the different training media such as classroom instruction, on-the-job training and e-learning. Harding, Kaczynski and Wood (2005) noted that in blended learning “…the conveniences of online courses are gained without the loss of face-to-face contact” (p. 56). Instructors want to introduce blended learning to help students who are unable to cope with only online learning; offer additional support to weaker students; wish to introduce students to technology; help students who have time and distance restrictions in attending classroom based courses and for university financial and staffing reasons. As Singh (2003) pointed out; blended is based on the idea that learning is not a one-off one-time phenomenon but a recognition that learning is a continuous ongoing process.

One of the areas of increasing interest in e-learning (and blended learning) is the use of remote laboratories or simulation software in improving the learning experience with a more interactive hands-on approach. Hands-on or experiential learning will thus be discussed next. The concept of experiential learning in a laboratory environment for engineers and technicians is then examined and its importance in learning will be assessed. Following on from this, the literature on remote and virtual laboratories is outlined. A recent survey done by the authors on the efficacy of e-learning and remote laboratories to engineers and technicians is then examined. The paper is concluded with suggestions on effective application of remote laboratories to training for engineers and technicians.

LEARNING BY DOING OR EXPERIENTIAL LEARNING

A phrase recently coined is e-learning2 (or ee-learning) or experiential learning (Trevitte & Eskow, 2007). As Eskow explains: “In experiential learning, the distinctive attributes of an everyday scene – its activities and settings, its obligations and entitlements, its excitements and boredoms, its spaces and places and people and the problems they deal with – serve as the primary textbook of learning” (p.1). He noted that ee-learning can bring the world and the classroom together using the computer and associated technology as the enabling medium. He stated further that the real world experiences cannot be duplicated in a simple lecture or classroom. Even a video game is limited.

As an extension to this experiential view of the world, in an engineering context, one of the challenges with e-learning is the lack of interaction with the instructor and the difficulty of using real tools to demonstrate and provide practical hands-on exercises (such as working with real equipment in an industrial automation environment) for the participants (Cooper, 2000; Cooper et al., 2003).

Schank (2002) pointed out the poor quality of e-learning that many users commented on. Although Shank (2002) was thinking along more general lines, he stated that learning by doing was an essential part of the learning experience:

Learning by doing works because it strikes at the heart of the basic memory processes that humans rely upon. We learn how to do things and then learn what we have learned is wrong or right. We learn when the rules apply and when they must be modified. We learn when our rules can be generalised and when exceptional cases must be noted. We learn when our rules are domain bound or when they can be used independently. We learn all this by doing, by constantly having new experiences and attempting to integrate these experiences into existing memory structures (Schank, 2002, p. 5).

It was hoped that this research would demonstrate that in applying a hands-on experience with labs to e-learning that Schank’s assertion above, of the importance of experiential learning would be validated.
LABORATORIES AND LABORATORY WORK

Huntley, Mathieu, and Schell (2004) defined a laboratory (or lab, as it will be henceforth referred to, for brevity) “as a room or building containing specialised equipment” (p. 398). Lindsay (2005) noted that a typical lab class “comprised a small group of students, and a demonstrator (often a postgraduate student), grouped around a piece of hardware located in a lab. Students typically conduct a series of experimental procedures as outlined in the lab handout, they record the data from the hardware, and they write up a report based on this data and the underlying theory in the week or two subsequent to the session” (p. 44).

Gandole (2005) added to this by remarking that a lab “should aim to encourage students to gain:

- Manipulative skills
- Observational skills
- Ability to interpret experimental data
- Ability to plan experiments
- Interest in the subject
- Enjoyment of the subject
- A feeling of reality for the phenomena talked about in theory” (p. 49)

Colwell, Scanlon, and Cooper (2002) noted that practical work and executing experiments helps students in learning science and engineering subjects. They quoted from Hewson and Hewson (1983) who stated that students need to engage in knowledge construction. This is difficult for students working in science and engineering as they “need to develop both conceptual and procedural understanding by appropriate actions” (Colwell et al., 2002). This required practical hands-on activity. Jochheim and Roehrig (1999) noted that doing experiments with live processes and equipment equips the engineering student with expertise in tackling engineering problems as well as improving their motivation. He added that many physical phenomena are difficult to understand and explain in words or textbooks but must be witnessed in action.

All the above indicated the need for practical work for students of engineering and industrial automation.

Trotter (2007) suggested a useful table to interpret student learning (Table 1).

Table 1
What Students Remember (reproduced from Machine Design p. 84 January 11, 2007)

<table>
<thead>
<tr>
<th>Absorption Results</th>
<th>Type of instruction</th>
<th>Level of instructional design</th>
</tr>
</thead>
<tbody>
<tr>
<td>90% of what they do</td>
<td>Simulations and games</td>
<td>High</td>
</tr>
<tr>
<td>70% of what they say or write</td>
<td>Interactive live e-class or seminar</td>
<td></td>
</tr>
<tr>
<td>50% of what they hear and see</td>
<td>E-course with audio and video</td>
<td>Medium</td>
</tr>
<tr>
<td>30% of what they see</td>
<td>E-course with visual, online self-study guides, and online powerpoint presentations</td>
<td></td>
</tr>
<tr>
<td>10% of what they read</td>
<td>e-mail, e-documents, and e-white papers</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>e-reading</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E-learning</td>
<td></td>
</tr>
</tbody>
</table>

This suggested that blended learning using interactive synchronous e-learning was perhaps appropriate for achieving high absorption learning rates with a score of 70% against 30% in only applying the asynchronous e-learning approach. It would also appear that a hands-on interactive approach with real equipment (using a lab, for example), could generate an absorption rate of 90%.

These comments suggested that synchronous e-learning with hands-on activities in a collaborative learning environment as a valuable component of blended learning could be successful. Hands-on activities using a remote or virtual lab is examined next.
Remote and virtual laboratories

Lahoud and Tang (2006) pointed out that many distance learning students found that traditional lab experiments were not an option due to geographical separation. They suggested offering some form of virtual or remote lab environment for distance learning students. They described the two possible solutions:

- Virtual labs comprising the simulation software running on a host machine; but they believed that it is difficult for students to achieve the required skills and practice. Often very powerful and expensive servers are required to make the simulations as realistic as possible.
- Remote labs are equivalent to the traditional lab environment in using real equipment but situated at a significant distance from the learner.

Figure 3 gives a diagrammatic representation of a remote lab with learners in different cities in the world engaged in hands-on activities with a lab situated in London.
A useful table showing the difference between traditional, remote and virtual labs is adapted from Auer, Pester, Ursutiu and Samaolia (2003) below.

Table 2

<table>
<thead>
<tr>
<th>Different Types of Labs and Their Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Local experimenter</strong></td>
</tr>
<tr>
<td>Real experiment</td>
</tr>
<tr>
<td>Virtual experiment</td>
</tr>
</tbody>
</table>

Ma and Nickerson (2006) referred to the impact that information technology has had on the creation of simulated labs and remote labs as useful alternatives to the traditional conventional labs. They pointed out that the effectiveness of these two new lab approaches as compared with the traditional hands-on labs was not examined in much detail in the research literature. They felt that the remote and simulated labs were an excellent way to share specialized skills and resources over a wide geographical area and thus reduce overall costs and improving the educational experience. Azimopoulos, Nathanail and Mpatzakis (2007)
concurred with this and emphasised the need for practical work as an important adjunct to the theoretical study.

Andria et al. (2006) indicated that it was important for students to achieve good practical training in a real working environment with instruments. They indicated that due to their high cost, labs are not as available as they should be and remote labs offered a good solution.

Ma and Nickerson (2006) noted that simulated labs were considered to be at least as effective as traditional hands-on labs. However Magin and Kanapathipillai (2000) believed that simulation could result in some disconnection between the real and simulated or virtual worlds. An additional problem was the often significant costs of a simulation system (in some cases, more than the physical lab). Remote labs are becoming increasingly popular and provided flexibility in terms of place and time for a student and they can also be accessible to far more students. However the educational effectiveness of remote labs was questioned by some, as students are likely be irritated by having a computer as an intermediary to the real world equipment (Keilson, King, Sapnar, King, & Sapnar, 1999).

Esche (2005) listed the benefits of the remote labs for students as follows:

- A more comprehensive experimental experience
- A more accurate representation of a hands-on experience
- Optimises their imagination and enthusiasm
- An asynchronous approach allows for more flexibility with instructors and students not being required at the same time
- Promotes self learning on the part of the student
- It allows for a more integrated self assessment approach

Insofar as the instructors (and their institution) are concerned, the benefits can be:

- They can easily add lab demonstrations into their instruction
- They can monitor the lab performance of students more rigorously
- Less scheduling problems due to excessive student numbers
- Fewer lab personnel required
- More flexible financial planning for expensive equipment is now possible
- Greater levels of safety can be achieved

A slightly more negative perspective was provided by Albu, Holbert, Heydt, Grigorescu and Trusca (2004) who suggested that remote labs were not as effective for training engineering students for the following reasons: minimal experience is provided in handling real equipment; there are less real world problems such as loose wiring and electrical contacts and the student is shielded from connecting equipment up incorrectly. They thus suggested considering using these remote labs as a prelude to real laboratories.

Virtual labs have not been discussed in much detail, as they are considered generally too expensive and there are some concerns about their efficacy for students (Ma & Nickerson, 2006; Magin & Kanapathipillai, 2000) mainly due to the difficulty in replicating the lab situation realistically and the students’ perception that this is merely a simulation. A few examples of remote lab applications are discussed below.

Cennamo et al. (2004) gave an example of a wind tunnel where the instructor and students connected from a remote site and executed various tests without any operators being present on site. This is useful for those organisations that do not have these types of experimental facilities. Lahoud and Tang (2006) designed a lab for experimenting with intrusion detection (IDS) and intrusion prevention (IPS) technologies with a maximum of 24 students; hence with only 16 lab hosts they broke the students into two groups who had different lab schedules. Finkelstein (2006) described an application of using a live online telescope with a student’s (Paul Stacey) comments about the experience with his astronomy lecturer: “...Ron used application sharing to show me how to use the Web interface that controls the telescope...I set the shutter speed and snapped pictures! The live nature of the session allowed us to examine each picture right on the spot” (pp. 27-28). Finkelstein remarked that immediate support and feedback from the instructor to the learner with hands-on interesting activities made for an outstanding online learning experience.

Almgren and Cahow (2005) believed that the factors that were improving computer-based engineering education were a desire to increase active and discovery learning, to make lab facilities available to the wider community and to provide students with more meaningful practical experiences. They believed that
the appeal for remote (or online, as they termed it) labs is due “to the increasing demand for active learning and flexible education, and for the appeal of implementing techniques of learning via discovery” (Almgren & Cahow, 2005, p. 3).

CURRENT RESEARCH ON BLENDED LEARNING AND REMOTE LABS

The authors undertook a comprehensive worldwide survey in August 2007 on e-learning and blended learning issues for engineers and technicians with 2,425 respondents. There was a fairly wide distribution of respondents across North America (19%), Europe (13%), Africa (14%) and Asia Pacific (52%). Most knew what e-learning or blended learning was with 73% indicating knowledge of this area. But in some respects with such a technically advanced group who would be using the internet extensively, it is surprising that there are still a large number (27%) who do not know what e-learning is. Only about 37% had actually attended an e-learning course. This indicates that the engineering industry still has a long way to go to catch up to the computer and business communities in the take-up of this technology, especially considering that the e-learning sessions could be free and of a duration of a few minutes. A convincing 50% indicated that online learning expenditure would either increase slightly or significantly with only 3% suggesting a decrease was going to happen.

An issue suspected and noted in numerous qualitative comments, is the relationship between (e-)learning training and size of organization. A direct relationship was identified \( p < 0.001 \) between the size of an organization and the attendance at e-learning classes ranging from an organization size of 1-100, with 46% undertaking an e-learning class to 62% for an organization greater than 10,000 employees.

A significant number (56%) felt online courses were not more engaging. A proportion of this would include people who have not actually attended online training and believe this to be the case without first hand experience. A very small percentage of 10% felt that online training is more engaging.

In examining the impact that hands-on training has made with remote labs and simulation software for those familiar with e-learning and blended learning, a large number (27%) used simulation software as part of their e-learning efforts. Only a small proportion (6%) used remote labs. This shows that there is a sizeable engineering population in the world today, who could benefit from this form of technology, in terms of addressing the earlier comments about boring e-learning content and making it far more interactive.

In the associated comments field (with a large number of about 30 comments), there was a telling comment about the use of remote labs and simulations: “Tried to but found it difficult” and “software didn’t run correctly on my computer”; indicating that the technology has been difficult to apply but perhaps the time is propitious to demonstrate in this research that it is possible and easy to apply.

A cross tabulation was performed with the other data gathered and there were some useful results. For hands-on training against that of job function \( p < 0.001 \), the training function was more likely to use remote labs, and human resources to use simulation software. However the number of respondents in training was thin (13 total); so this result should be treated with caution. Secondly, for hands-on training against that of online courses being more engaging or motivating \( p < 0.001 \) there was a significant direct relationship between engaging and using remote labs. However for simulation software, there was no significant relationship. It is possible that the words simulation software mean different things to the respondents; hence the difference. The precise reasons for this difference are difficult to gauge; but it is likely that the training personnel would be keen to try new learning technologies of which remote labs are one.

As suggested in the literature review, some disquiet was expressed in the comments by the respondents on the lack of hands-on experiences with the standard e-learning approach. The general view expressed was that it was impossible to undertake training of engineers without hands-on practical experience with equipment. This was essential for the training of engineers and technical professionals, and this could only be achieved in a classroom environment where the instructor and equipment was physically present. These comments are supported by the research done by M. Phillips (2006), where many noted the need for more “hands-on” training and concerns as to whether e-learning would be able to provide this. A useful and detailed suggestion was to split the topics into different categories: web-based to fit into the student’s lifestyle, classroom to allow them to focus on one subject and hands-on to solidify the learning. Finally, one user noted that it ultimately depended on the person’s learning style – but getting “trades staff to sit at a PC to learn is a challenge both in skill, attitude and time.” Hands-on training with real equipment was thought useful to reinforce the theoretical learning.
CONCLUSION

Suggested ways of applying this technology to engineering learning are to promote the use of hands-on remote labs to enrich e-learning, create a directory of remote labs throughout the world; to market this vigorously to everyone wanting to experiment with these labs and to encourage the development of open (against proprietary) software to allow easy creation and use of these labs.

In conclusion, this paper has summarised and analysed the impact remote laboratories have on an e-learning and blended learning environment. The research undertaken indicated that there is strong growth anticipated in e-learning and blended learning training but minimal current usage of e-learning courses by engineers and technicians. Many respondents indicated reservations about the lack of hands-on training in using these new technologies. The hands-on approach is critical for engineering training as contrasted with that for other fields of endeavour such as banking, insurance and law. There was also evidence in the research of a low take-up in using remote labs and simulation software in the e-learning environment. Certainly, there were numerous comments indicating difficulty in working with the lab technology indicating that the technology has been difficult to apply. It is believed that the time is propitious to demonstrate that remote labs are indeed easy to apply and will make a major contribution to engineering learning in the future.

REFERENCES


EVALUATIONS AND QUALITY: A SYMBIOTIC UNION FOR EVIDENCE-BASED DECISION MAKING TO AFFECT CHANGE

Chenicheri Sid Nair and Lorraine Bennett
Monash University
Australia

ABSTRACT
In recent years greater government and public scrutiny of universities is demanding more justification and accountability of public expenditure. The rhetoric espouses the need to document and demonstrate tangible evidence of the impact and quality of teaching and research activities undertaken at universities and this focus has led to government funding models being directly linked to quality learning outcomes. Australian universities have responded by implementing a range of quality assurance programs. Fundamental to whatever quality model being applied is an acceptance of the importance of collecting feedback from students about their study experience. A consistent pattern emerging from the data is evidence of a strong correlation between classroom environments, learning and satisfaction (e.g., Nair & Fisher, 1999). While most universities regularly conduct student surveys, to date the weakness reported across many, is that the valuable and growing data sources are not being routinely interrogated and acted upon to bring about improvements. This paper outlines a case study of a systematic improvement strategy that was developed at Monash and rolled out initially in the Faculty of Pharmacy utilizing as the primary data source student feedback. The results are promising and suggest that a targeted intervention approach developed strategically and molded to the internal context of the faculty not only can lead to improvement but demonstrates to students that their feedback is the backbone to change.

INTRODUCTION
Many factors have played a role in the changing landscape of higher education in Australia in recent years. These factors include: greater government and public scrutiny of universities; the introduction of new competitive government funding models linked to quality outcomes; an increased focus on compliance and reporting; a greater reliance on full fee paying students and other funding sources and at the same time a growing demand for university places from an increasingly diverse student population, particularly international students. Fundamental to all these factors is quality and accountability. Further, with the inception of the Australian Universities Quality Agency (AUQA) in 2001, Australian universities have participated in quality reviews in which they were required to demonstrate that they have clear policies, systems and procedures in place to ensure a quality experience for their students. Universities have embarked on this ‘accountability journey’ by reexamining their pedagogy and curriculum and in particular by obtaining feedback from students using a variety of methods.

The most popular method for obtaining student feedback, with a view to better understanding the needs of their students, are student evaluations and most universities now have student evaluation systems in place to routinely capture students’ perceptions. Such evaluations provide a number of uses. These include: diagnostic feedback about teaching that assists the development and improvement of teaching strategies; research data to underpin further design and improvement of units, courses, curriculum and teaching; a measure of teaching effectiveness that may be used in decision making such as performance management and appraisal; information to current and potential students in the selection of units and courses; and, a measure for judging the quality of units and courses increasingly becoming tied to funding (Bennett, Nair and Wayland, 2006). The first three purposes are widely recognised as the basis for many evaluations (eg, Fraser 1998; Marsh, 1987) whereas the latter two purposes are relatively new.

Although there has been substantial research undertaken on the effectiveness of student evaluations some still question their validity (e.g., Marsh & Dunkin, 1997; Nasser & Fresko, 2006). One common criticism is that students lack the wisdom and experience to evaluate the effectiveness of their course or teacher. However, research shows a high correlation between course-end ratings and ratings by peers, administrators and alumni (e.g., Marsh & Dunkin, 1997). In fact there is also clear evidence that feedback from students’ evaluations can lead to improved teaching effectiveness (e.g., Marsh & Dunkin, 1997; Marsh & Roche, 1993).

For Monash the usefulness and significance of evaluation measures related to the quality of the units, courses, programs and student experience are reflected in the values, aspirations, strategic documents and the nature of the organization (Monash University, 2004a, 2005). While there is growing awareness across universities of the purposes of evaluations, it is only recently that universities have started to focus on the need to act on the data collected in a systematic and strategic manner. In terms of the standard quality cycle (plan, act, monitor-evaluate and improve) this addresses the improvement phase and is sometimes referred to as ‘closing
the quality loop’. This paper describes a case study of a systematic improvement strategy that was developed at Monash and rolled out initially in the Faculty of Pharmacy utilizing the university wide unit (subject) evaluation data as the primary data source to effect change. Pharmacy was selected for early intervention because the faculty was small and it was felt that a trial would be relatively easy to manage.

THE APPROACH

Data Collection

In 2005 Monash policy on evaluating units was amended to require evaluation of each unit at least once every year it is offered instead of the previous 3-5 year cycle. Evaluation is undertaken through administration of a survey which contains 10 standard University questions common to all faculties with the option to include up to ten further questions of their choosing common to all units within the Faculty. To facilitate the administration of the survey to all units on all campuses, the Centre for Higher Education Quality (CHEQ) introduced a new Survey Management System for the evaluation of units with the ability to have both paper and web based versions (Nair and Wayland, 2005). Every student enrolled in a unit at Monash is now given the opportunity to provide feedback annually on unit quality. In 2006 and 2007 over 6,800 and 8450 units respectively were evaluated in comparison to less than 700 units typically being evaluated each year under the previous policy.

The Institutional Strategy

In 2005 the university also established the Centre for the Advancement of Learning and Teaching (CALT) which, working closely with CHEQ, was charged with the responsibility of acting on the growing body of student feedback data to bring about unit improvement. The approach adopted involved CHEQ and CALT staff to work collaboratively with faculties, drawing on student evaluation data and other performance measures, to establish goals and priorities to improve the quality of learning and teaching and consequently student performance and satisfaction levels. The guiding principles used to underpin the strategy included:

- working primarily from the unit evaluation data sources,
- targeting poorly performing units as a priority,
- establishing response teams to go into faculties to affect change,
- linking staff and student development support,
- focusing initially on aspects which presented minimum obstacles to change,
- providing concentrated support over a short term to achieve high impact,
- documenting and demonstrating improvement as a consequence of the actions taken.

The four phases of the quality cycle - Plan, Act, Evaluate (Monitor and Review) and Improve were used as the framework for the methodology. The entire process was designed to take place over a six to eight week period to enable the improvements to be made where possible in time for the next teaching cycle.

Trialing the Strategy

By mid-semester 1, 2006 the CALT/CHEQ response team initiated a trial run of the strategic approach to improvement in the Faculty of Pharmacy. A response team is a defined number of staff from CALT and CHEQ dedicated to work with a faculty to address issues arising from feedback data provided by unit evaluations. This team usually comprises a member from CHEQ and up to four members from CALT. An important cornerstone of this strategy was to target poorly performing units as a priority. Inclusive in the strategy was also to value or acknowledge highly performing units, often referred to as exemplars of ‘good practice’.

Final selection of the units to target involved a fairly detailed process. Initially the bottom 25% performing units for the faculty based on the ‘satisfaction item’ from second semester 2005, were identified and other units where items were rated 10% below the faculty average for that item were added to the list. Other factors which were taken into account included the class size, the response rate and, for units taught on more than one campus, any campus specific trends. It was also helpful to identify sequential units and units that were in the same year level or course. During the selection process discussions with faculty staff including the associate dean teaching and relevant program, course and unit leaders were essential as they often flushed out contextual information which was not evident from the data sets. Although the ‘satisfaction item’ was used initially to select the units in the spotlight, further analysis was carried out on each of these units to see if other items in the survey were below the mean. The responses to the open ended questions for these units (the qualitative data) were also reviewed for further clues to possible areas for improvement.
Eight out of the ten units in the bottom 25% of units were initially selected for the first trial and staff from five of these units agreed to participate in the program. The response team worked intensively with these faculty staff on the areas that were identified in need of improvement. The types of activities that were provided by CALT staff included:

- reviewing and reshaping unit objectives;
- aligning assessment tasks to objectives;
- providing advice and ideas on innovative assessment tasks;
- reviewing learning materials;
- providing unit guide and learning material templates;
- conducting workshops on giving effective student feedback;
- highlighting the role of learning objectives in curriculum development.

The response team faced a number of challenges in the implementation phase of this strategic process. Some of these challenges included: finding the best way to introduce the process within the faculty; (staff were generally positive especially the Dean, Associate Dean Teaching and Faculty Manager but as it was a new process, everyone needed to learn as it unfolded); high workloads of staff often limited their availability for meetings to discuss the results and implement change; and the perceived ‘threat’ faced by academics in general when engaging with poor feedback data and debate on the validity of the unit evaluation survey data needed to be handled sensitively. To address many of these challenges the response team regularly met with staff and students involved in the units to test out ideas and to identify how else the unit could be improved. A detailed report of this case study ‘Implementing Strategic Policy for Quality Improvement in Teaching and Learning: A Case Report from Monash University’ has been prepared by the key response team members (Spratt, Gilbert, Luckenhausen and Roller 2007).

FINDINGS FROM THE CASE STUDY

The data in the Table 1 below indicates that when the units were next evaluated, in second semester 2006 after the intervention program, the mean for the satisfaction item in four of the units improved with the fifth unit reporting a marginally insignificant lower satisfaction at 3.20 (3.23 cf 3.20).

<table>
<thead>
<tr>
<th>Units</th>
<th>2005*</th>
<th>2006*</th>
<th>Mean change (2006-2005)</th>
<th>% Change of Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>3.68</td>
<td>3.85</td>
<td>0.17</td>
<td>4.6 ▲</td>
</tr>
<tr>
<td>Unit 2</td>
<td>3.28</td>
<td>4.00</td>
<td>0.72</td>
<td>22.0 ▲</td>
</tr>
<tr>
<td>Unit 3</td>
<td>3.00</td>
<td>3.50</td>
<td>0.50</td>
<td>16.7 ▲</td>
</tr>
<tr>
<td>Unit 4</td>
<td>3.23</td>
<td>3.20</td>
<td>-0.03</td>
<td>0.93 ▼</td>
</tr>
<tr>
<td>Unit 5</td>
<td>3.07</td>
<td>3.29</td>
<td>0.22</td>
<td>7.20 ▲</td>
</tr>
</tbody>
</table>

* Mean on satisfaction item

Staff involved in overseeing the intervention reported that it was their contention that the substantial improvement in Unit 2 (22% improvement in the mean for the quality item and substantial improvements across all other university and faculty items) was primarily due to the commitment and perseverance of the unit coordinator, and an effective collaborative relationship between the unit coordinator, CALT staff and the relevant VCP IT staff.

Collaboration was a key element of the trial and as a result of the work of the intervention team the VCP Faculty Education Committee mandated that there would be more continuous assessment in all units across the VCP programs. The provision of student feedback was also taken up by the faculty as a priority and it agreed to continue its commitment to improving student feedback through for example, implementing the ‘Lectopia’ pilot project, using audience response systems in large lecture classes, and growing the use of online and multi-media learning support strategies. CALT supported staff development by conducting sessions relevant to the project’s findings (e.g. learning objective and feedback strategies).

The impact of the improvements achieved in 2006 appears to be sustained in 2007 unit evaluations. Of the four units surveyed in semester 2, 2007, all but one improved from the 2005 means and two improved further from the 2006 means.
LIMITATIONS

While the trial provided several good ideas to add to the support activities it also highlighted the need for clarification and further detail throughout the process. The items below outline some of the suggestions that have been subsequently incorporated into the improvement methodology since the initial case study:

- One particular point raised by team members was the need for the strategy to be sufficiently flexible to enable contingency plans to be promptly implemented as intervening variables such as conflicting demands on faculty staff time cut into the program. (This is being addressed in the revised methodology, particularly with respect to endorsement of the process by the Dean and ADT so that staff understand the importance of the work).

- A concern expressed by faculty staff was that the identification of the target units relied too much on results from student unit evaluations. Staff were assured that this was simply a way into the data and that other data sources and information (e.g., student progress, retention and failure and grievance rates) were taken into account when working with the units for improvement. (From 2008 Monash is introducing a Unit and Course profiling tool using Cosnos which will facilitate the access to such data).

- Faculty staff also expressed concern that the strategy only focused on poorly performing units and that there was not sufficient acknowledgment or celebration of the top performing units. This view is respected by the team and every effort was made to utilize materials and examples of highly performing units. (From 2008 the methodology will be expanded to celebrate teaching excellence through showcase activities, by encouraging staff to apply for teaching awards and through peer mentoring programs).

- A significant lesson from the trial was the need to build strong relationships at all levels within the faculty and to embed the strategy with a comprehensive communication plan. Even though the team worked with and through the dean, faculty manager and associate dean teaching some staff did not engage in the process and were unaware of the extent of the team’s activities. (it is anticipated that the additional focus on recognizing and rewarding excellent teaching will help create great awareness and interest in improvement).

CONCLUDING REMARKS

The overall conclusion is that the strategy is worth pursuing as the results are encouraging in terms of the improvements in the overall student satisfaction levels recorded from 2005 to 2006 and subsequently 2007. The results suggest a targeted intervention approach developed strategically and molded to the internal context of the faculty has the advantage of addressing issues that are easily correctable. This is in line with research findings in that there is a strong correlation between classroom environments, learning and satisfaction (e.g., Nair & Fisher, 1999).

This first attempt at a comprehensive approach to implementing targeted, systematic improvement in response to student unit evaluations shows not only a great deal of promise but demonstrates to students that their feedback is the backbone to changes. Further, the ability for faculties to also use the data to improve teaching and learning has resulted in students gaining confidence in the new unit evaluation process and is consistent with research findings (e.g., Leckey & Neill, 2001). This is demonstrated with the increase in overall response rates since the implementation of the new system for the unit evaluations. Response rates have

Table 2
Mean Comparisons over 2005-2007 of the Satisfaction Item for Four of the Units Involved in the Trial

<table>
<thead>
<tr>
<th>Units</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit 1</td>
<td>3.68</td>
<td>3.85</td>
<td>3.95</td>
</tr>
<tr>
<td>Unit 2</td>
<td>3.28</td>
<td>4.00</td>
<td>3.77</td>
</tr>
<tr>
<td>Unit 3</td>
<td>3.00</td>
<td>3.50</td>
<td>Not surveyed</td>
</tr>
<tr>
<td>Unit 4</td>
<td>3.23</td>
<td>3.20</td>
<td>3.10</td>
</tr>
<tr>
<td>Unit 5</td>
<td>3.07</td>
<td>3.29</td>
<td>3.70</td>
</tr>
</tbody>
</table>
increased from just over 32% to nearly 41%. This translates to actual responses increasing from 39,041 to 55,334.

The information thus obtained from student feedback has resulted in raising awareness not only within the faculties but as well in the University. What has transpired is the initiation of change which is at the heart of evaluations, and is this case, is improvement in teaching and learning. Although the application stage of the results in the quality cycle is in its infancy, the future promises to be challenging in improving student learning experiences at Monash. Consistent with research findings, the University has taken the view that feedback from students is not only important and integral to the quality cycle but such feedback provides reliable and valuable information to which the University must act to meet the needs of their customers. Further, the University has realised that the information contained within student feedback questionnaires to be important in measuring how the university is performing with respect to student perceptions in academia and as a whole in the university. Comfortably, it can be concluded that it is unlikely that the efforts to better the learning environment would not have taken place without the stimulation of such a strategic approach.

Consistent with this transformation is the recognition that Monash has received in its efforts in improving the student learning environment. This recognition comes externally in two ways. First an external review of CHEQ in 2003 highlighted the dramatic change in the landscape of evaluations:

“The dramatic expansion of the university’s quality tracking and improvement processes, from a focus on the use of teaching evaluations when the Centre was first constituted to the currently extensive suite of instruments and their associated administration, processing, analysis and reporting strategies.”


Second, the breath of the impact of process was recently acknowledged by the AUQA audit of Monash in 2006:

AUQA commends Monash University for its rigorous evaluations of student satisfaction with the study experience, through the Monash Experience Questionnaire and unit evaluations, that have contributed to the improvement of satisfaction with the experience.

Report of an Audit of Monash University (AUQA, 2006)

Finally, this paper provides science educators not only the practical evidence demonstrating what has been consistently proven in the research literature, that is the reliability and validity of student feedback data but that acting on student feedback data can improve the student learning environments.

REFERENCES


A DIGITAL IMPLEMENTATION OF INTEGRATOR BY FPGA FOR APPLICATION WITH TEACHING AND LEARNING IN THAI ELECTRONIC CLASSROOM

Chaiyong Pagarapun,
Udonthani Rajabhat University, Thailand.

Abstract
Although, the integrator is easily for digital implementation by digital circuits but still difficult for application with teaching and learning. Due to digital implementation have problems with users to change design parameters difficult for several times. It has been shown that the integrator in digital by application such as digital control system, modulator and more electronic circuits so it very important. Also previous research suitable for actually implementation on chips. Moreover, because it is parameterizable, users can change design parameters easily by software design. The proposed implementation is based on the transformation from analog integrator to the digital version for application with teaching and learning relate with digital knowledge. The design was verified by software is VHDL Language (VHSIC hardware description language) and then implemented on a Field Programmable Gate Array (FPGA) chip. Finally, to conduct proposed testes with students in Department of electronic technology Udonthani Rajabhat University by laboratory (LAB) practice.

Keyword: Integrator, Field Programmable Gate Array (FPGA), VHDL (VHSIC hardware description language)

Introduction
Integrator has been widely used in electronic and electrical control systems such as modulator refer to reference[2], Proportional-Integral (PI) control refer to reference[3] or apply to control systems. While the basic block diagram of integrator to show in Fig.1: So the integrator it suitable for interesting in this research purposes, it related both for subject of analogue and digital. Also, FPGAs are increasing importance both in commercial as well as research settings. Thus, the probability of a student after graduation working on FPGA-based circuits is higher than that of him developing to apply with education or industry. The theory and practice of working with FPGAs have become a major part of the curriculum as well as the research at the department of electronic technology Udonthani Rajabhat University Thailand.

This paper proposes a digital integrator for application with teaching and learning, its can be testing performance of students before and after learned by keep data from students of Department of electronic technology Udonthani Rajabhat University Thailand by LAB practice.

Fig.1: Input Signal \( \int \) Output Signal

Block diagram of basic integrator

Review of Digital Integrator

The integrator act as low pass filter which results in attenuation of high frequency component from the output of such modulator is a sample circuits. The basic blocks of integrator are transformed from Time-domain (into z-domain for discrete-time (digital) implementation. Where \( t V \) it is the input signal and \( V(t) \) is the output signal of integrator. The following section describes the basic z-domain transformation of the basic block of integrator show in Fig.1 and Fig.2.
Digital Implementation of the Integrator

A first order RC integrator is shown in Fig 1: If the amplifier gain is assumed infinity (∞) value, the s-domain transfer function of the integrator can be written as:

$$\frac{V_o(z)}{V_i(z)} = -\frac{1}{RCz}$$  \hspace{1cm} (1)

Neglecting the sign, the bilinear z-transformation of equation (1) is given as (3):

$$\frac{V_o(z)}{V_i(z)} = -\frac{T(1 + z^{-1})}{2RC(1 - z^{-1})}$$  \hspace{1cm} (2)

Rearranging equation (2) one obtains:

$$s = -\frac{2(1 - z^{-1})}{T(1 + z^{-1})}$$  \hspace{1cm} (3)

Where, in equation (1)

$$V_o(z) = a_0V_i(z) + a_1V_iz^{-1} + b_1V_iz^{-1}$$  \hspace{1cm} (4)

Where, $a_0$, $a_1$, and $b_1$ is constant coefficient can be show in equation (5) to (7) and $f_s$ is frequency of integrator defined by inverse time constant of $T$ in equation (8)

$$a_o = \frac{T}{2RC}$$  \hspace{1cm} (5)

$$a_1 = a_0$$  \hspace{1cm} (6)

$$\dot{a}_m = a_1 = a_0$$  \hspace{1cm} (9)

$$V_o(z) = a_mV_i(z)(1 + z^{-1}) + b_1V_iz^{-1}$$  \hspace{1cm} (10)
Equation (4) represents the output of a recursive integrator in z-domain. The block diagram realization of equation (10) is shown in Fig 3: The analogue integrator shown in the left side of Fig.4 can be replaced by the digital integrator in right side of Fig.4, where the delay $z^{-1}$ effected with the integrating time and frequency can be implemented by a register.

Refer to reference (5), Srivastava Fig.4: Transformation Method of Digital integrator

Block diagram of the integrator comparisons method to show by flow chart Fig.5: The proposed implementation by software design is left side block diagram.
Experimental

The VHDL program simulation was used for the primary tests of the digital implementation to show by below software testing. The integrator it tested to feed sine function as equation (11) is input sine signal and parameter value can be define by software as below sample. The simulation results show that it can generate the integrator as well as the analog as shown in Fig. 6:-Fig. 8:

Software Testing

Library IEEE;
USE IEEE.STD_LOGIC_1164.ALL;
USE IEEE.STD_LOGIC_arith.ALL;
USE IEEE.std_logic_signed.all; Parameter definitions
USE ieee.math_real.all;
USE work.sine_package.all;

**------------- Test bench of integrator -------------**

entity integrator_2com_test is
generic(
  n : natural := 16;
  m : natural := 50;
  sys_freq : integer := 500; -- system (sampling) clock in kHz
  sin_freq : integer := 50; -- sinusoid frequency in Hz
  sw_freq : integer := 2; -- switching frequency in kHz
  tau : real := 1.7;
  vp_sim : real := 5.5;
  vmin : integer := -63;
  vmax : integer := 63;
  vplus : real := 11.0;
  vminus : real := -11.0;
);
end integrator_2com_test;

Where, in equation (11) is testing function by sine signal.

\[ \int \sin ax \, dx = -\frac{1}{a} \cos ax + c \]  \hspace{1cm} (11)

Fig. 6: Sine to Cosine Signal

Simulation Result

Fig. 7: Analogue Signal
Conclusions

The integrator in this paper is proposed to solve problem of the teaching and learning relate with digital knowledge. The simulation of the digital system shows that it can generate the integral signal as well as the analog implementation. For the actually tested with students Department of electronic technology Udonthani Rajabhat University by laboratory (LAB) practice as below information.

Divide students are five groups for testing understand of students to check by experimental result from LAB practice as well statistic graph in Fig 9:

This method it has been tested with the department of technology electronic Udonthani Rajabhat University Thailand for development teaching and learning of knowledge digital integrator in LAB, before and after learning.

Proposed method can be development students is better as show in upper line of Fig 9:

The ways to development can be combining implementation with several digital systems in the future.
Reference
Andreas Koch, Ulrich Golze “FPGA Applications in Education and Research”, Technical University Braunschweig, Germany.
Yajuvendra Nagaonkar and Mark L. Manwaring, “An FPGA-based Experiment Platform for Hardware-Software Codesign and Hardware”, Brigham Young University, USA.
E-LEARNING ISSUES: PROBING PEDAGOGY, INTERFACE AND CULTURE

Jeremy Pagram and Penporn Pagram
Edith Cowan University
Australia

ABSTRACT

E-learning is a new facet of educational technology which many countries both developed and developing are rushing to embrace. Perceived benefits in both cost of delivery and educational outcomes are usually the driving force. This has led to a new phase in the globalisation of education, with education being sold on the world market like any other product. With this global trend come issues that go beyond those of content, delivery and even language for example, e-learning materials are very expensive to produce, so its success largely depends upon economies of scale that unfortunately leads to a one size fits all pedagogy. Even locally produced e-learning materials can suffer in this way, as often the content is local but the instructional model is international. The result is that often local content is plugged into overseas e-learning templates without the model of instruction being modified to suit the learning style or the culture into which it is being delivered. This paper reports upon a small research project in which an analysis of a number of Thai e-learning web sites was undertaken; looking at each of the sites individually in terms of pedagogy, interface and cultural appropriateness. The e-learning sites were chosen from different types and levels of education institutions within Thailand. While each site chosen was unique in style and purpose, some cross-case analysis was possible through the use of common instruments.

INTRODUCTION

Countries throughout the world are applying advances in telecommunication and information technology to change the way education is delivered and this global trend is also being felt in Thailand. The book Education in Thailand 2002/2003 (Office of the National Education Commission, 2003, p.84) states that “Realising the important role of technologies for education is important in enhancing the competitiveness of Thailand and its people in a knowledge-based economy and society. Both the 1997 Constitution of the Kingdom of Thailand and the National Education Act of B.E.2542 (1999) also specify using technologies for education”. Thus the Thai education system is changing as globalisation and modern society impact upon Thai life. Many educational institutions in Thailand are interested in e-learning, as it is perceived as the “new style of learning”. E-learning changes not only the “how” we learn (more individual in style), but also, “who” we learn with (computers/internet). The promotion of “ICT in education” through “the Ministry of ICT” and “ICT focused governments” promoting Thailand as being the Asian leader of the Internet within five years (GoodNet’s News, 2004) are making large scale adoption of e-learning a reality in many Thai educational institutions.

Copying an e-learning pedagogical or interface style from another country may not suit the needs or content of Thai education. Undoubtedly, there are potential issues and dangers facing Thailand in its move to utilise ICT in education. Ainley, Arthur, Macklin & Rigby (2001, p.60) suggested that it was important that those responsible for program design and program delivery were able to draw upon a range of teaching and learning approaches and media, according to the needs and preferred learning styles of target groups of students. Thus, using ICT, especially e-learning, in Thai society, culture and history which is different from other countries needs to be examined carefully.

This paper describes part an investigation that used evaluation techniques to ascertain if the pedagogical and interface designs used in selected Thai e-learning materials were appropriate. Six Thai e-learning web sites were analysed in terms of particular pedagogical, interface and cultural aspects.

METHODOLOGY

The analysis was conducted by examining subjects/courses that are making use of e-learning in Thailand. This involved looking at the mode of e-learning, the pedagogy and interface design used, as well as the bandwidth and technology access needed. Analysis of the e-learning Web sites was through instruments developed for this purpose for pedagogy and interface design by Professor Tom Reeves from the University of Georgia (Reeves & Reeves, 1997) (Reeves & Hedberg, 2005). These were supplemented by a number of cultural dimensions based upon the work of Hofstede. Hofstede (2001, p.29) established the cultural dimensions while undertaking research in research in 50 countries (including Thailand). Those chosen for use in this investigation were:

391
• **Power distance**, which is related to the different solutions to the basic problem of human inequality

• **Uncertainty avoidance**, which is related to the level of stress in a society in the face of an unknown future

• **Individualism** versus **collectivism**, which is related to the integration of individuals into primary groups

• **Masculinity** versus **femininity**, which is related to the division of emotional roles between men and women

• **Long-term** versus **short-term orientation**, which is related to the choice of focus for people’s efforts: the future or the present

The selection of e-learning Web sites was not meant to be definitive, but provide an insight into the styles, types and levels of e-learning materials currently available in Thailand. Although there are a lot of e-learning web sites, it was decided to examine web sites existing on the Internet that anyone could access without enrolment and were available online without registration or within registration as a guest. The researcher limited these to six web sites representative of different types of education institution. They included one government university web site, one cooperative university web site, one cooperative university and business web site, one business web site, and two public school web sites from different areas. These locations were selected based upon their reputation for using new technologies in education. Web sites are de-identified for the purposes of reporting. The details of the sites chosen are described in Table 1.

Table 1  
*The Details of the Web Sites*

<table>
<thead>
<tr>
<th>Code</th>
<th>E-learning site analysed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uni</td>
<td>A university providing for students off campus. The investigation looked at a History unit in Thai language at degree level.</td>
</tr>
<tr>
<td>Co-Uni 1</td>
<td>More than two universities cooperating at certificate, Bachelor and Masters levels. The investigation looked at English for Communication unit at degree level.</td>
</tr>
<tr>
<td>Co-Uni 2</td>
<td>Universities cooperating with commerce for the public who want to learn at certificate level. The investigation looked at the course of English for living.</td>
</tr>
<tr>
<td>Com</td>
<td>A commercial e-learning site for adult students undertaking short courses at certificate level. The investigation looked at the unit Introduction to Commerce.</td>
</tr>
<tr>
<td>School 1</td>
<td>A public high school 1, all e-learning was investigated.</td>
</tr>
<tr>
<td>School 2</td>
<td>A public high school 2, all e-learning was investigated.</td>
</tr>
</tbody>
</table>

The e-learning sites were examined using the three instruments. The first was Reeves Interactive Learning on the World Wide Web Dimensions, which look at the underling pedagogy used. The second was Reeves Interface Design Dimensions, was used to examine the appropriateness of the interface for the intended user. The third was a subset of Hofstede’s Cultural Dimensions looked at how suited the materials are for Thai culture. The results of this analysis are shown graphically in Figures 1, 2, and 3 respectively.
Figure 1. Interactive learning on the World Wide Web dimensions.

- **Pedagogical Philosophy:** All websites followed an instructivist pedagogy that emphasises the importance of goals and objectives using a direct instruction. The learner is regarded as an empty vessel to be filled with learning. Every learner learns the same content with the same procedures without concern for different backgrounds or existing knowledge. Content is divided into independent sections. Direct instruction is used with a sharp definition of content and knowledge measured with closed response tests.

- **Learning Theory:** All websites focused on behavioural psychology where the learner is guided by the instruction through the content provided. The arrangement of stimuli, response, feedback, and reinforcement are provided to every learner through short presentations of content, multiple choice questions and right or wrong feedback. Most evaluation relates directly to the contents without cognitive thinking. There was no evidence of using learners’ previous experiences.

- **Goal Orientation:** All websites were very sharply focused. They established the objectives and outcomes, content and the method of evaluation to support the objectives. Most content was presented directly to the learners in order to achieve the objectives.

- **Task Orientation:** All web sites were judged to be the middle between academic and authentic. The School 1 and School 2 had a more authentic focus and the Uni was more academic focused than others. While most of the content was abstract and theory based, they tried to provide examples as much as possible, using pictures, video, sounds and animation.

- **Source of Motivation:** All web sites’ motivation was judged to be the middle. They are neither, strongly extrinsic or intrinsic. However, the School 1, and 2 used much more intrinsic motivation as
they provided general knowledge, students’ work and a test to support the curriculum. The Uni site used more extrinsic motivation as its content was directly concerned with the achievement of the course while the Co-Uni 1 and 2 played on both modes of motivation as the content focused on both general knowledge and training.

- **Teacher Role:** All web sites were didactic with the content to supplement the courses. Although the web acts as a teacher, there is still a teacher in the classroom. The web sites provided content to support learners to review the lessons. Some web sites provide the web links for further knowledge related to the content.

- **Metacognitive Support:** Most web sites did not have metacognitive support. There were no signs of accommodation for individual differences. The learner received the content without monitoring individual learning strategies although the Co-Uni 1 and 2 sites provided a little flexibility in choices of learning.

- **Collaborative learning Strategies:** All web sites do not support collaborative learning strategies. Learners learn individually, no activities for learners to work together in pairs or small groups to accomplish shared goals.

- **Cultural Sensitivity:** All web sites were in Thai (except the English subject) and for only Thai people and they provided content that was not incompatible with Thai beliefs. However, the web sites did not consider other cultures in design; they scored between insensitive and respectful in terms of cultural sensitivity.

- **Structural Flexibility:** Most web sites were flexible, none of them had a limited time and/or place for learning. However, the multimedia on the web sites such as animations or sounds was a possible barrier for learners who did not have compatible computers.
INTERFACE DESIGN

Legend

<table>
<thead>
<tr>
<th>Uni</th>
<th>Co-Uni 1</th>
<th>Co-Uni 2</th>
<th>Com</th>
<th>School 1</th>
<th>School 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td>Difficult</td>
<td>0 1 2 3 4 5 6 Easy</td>
<td>Difficult</td>
<td>0 1 2 3 4 5 6 Easy</td>
<td></td>
</tr>
<tr>
<td>Navigation</td>
<td>Unmanageable</td>
<td>0 1 2 3 4 5 6 9 10 Manageable</td>
<td>Coordinated</td>
<td>0 1 2 3 4 5 6 9 10</td>
<td></td>
</tr>
<tr>
<td>Cognitive Load</td>
<td>Violates Principles</td>
<td>0 1 2 3 4 5 6 9 10 Follows Principles</td>
<td>Aesthetics</td>
<td>Displeasing</td>
<td></td>
</tr>
<tr>
<td>Mapping</td>
<td>Information Presentation</td>
<td>0 1 2 3 4 5 6 9 10 Clear</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Screen Design</td>
<td>Media Integration</td>
<td>0 1 2 3 4 5 6 9 10 Coordinated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Functionality</td>
<td>Dysfunctional</td>
<td>0 1 2 3 4 5 8 9 10 Highly Functional</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 2: Interface design dimensions.

- **Ease of Use**: All had a similar level of ease of use, using consistent and logical menus and controls, following the standard windows interface. Some of them provide only text without any multimedia. Some web sites give options for high and low bandwidth and computer capability. Also, some web sites check the users’ computer before learning and the learners can download the free software for use within the program. However, there are problems with access for learners who do not have the high speed internet access or have low specification computers.
- **Navigation**: All web sites had logical icons and arrows for learners. The learners would know where they were within the content and how to go to other parts. However, some web sites did not have words for navigation, and did not have an orientation for that navigation for learners. Thus, novice learners might take time to learn the navigation by themselves.
- **Cognitive Load**: The web sites with less multimedia did not cause confusion for the learners. They can follow the program of content easily. Only the web sites on which the learners have to do many steps to find the content such as choosing and installing software to suit their computer before going forward, and having to point to an icon before listening to sounds, or to adjust sounds and video movement, or to hide the icons or pictures.
- **Mapping**: Mostly, in all web sites the learners were shown a map of the course at the beginning. Apart from that, the web sites did not show again unless the learners go back to the starting point. Some web sites have the numbers of the lessons on each page but cannot use it for navigation. While there are minor topics in each major topic, none of the web sites let the learners know how many topics to go until finished. However, most web sites shows details of the major topic on each page and let the learners know how many minor topics.
- **Screen Design**: The design of many screens for all web sites was quite simple. Mostly the icons were on the left, the content was on the right. Sometimes there was a video clip of the lecturer on the top or
the left of the content. However, some web sites had too many graphics, pictures and animations on the screen.

- **Information Presentation:** For all web sites the information was mostly presented with a clear font style, size and colour. However there was variation with letter size and colour within sites. Some web sites have only one size and one colour but some have too many different letter size and colour combinations that would cause learners confusion.

- **Media Integration:** Some web sites had no multimedia and only text. Some web sites have various media (text, graphics, audio, video, etc.) but they seem to not integrate properly e.g. having a song play all the time, the graphics do not suit to the text, or a video has different dialogue with the text.

- **Aesthetics:** All web sites presentation was judged to be good. Some web sites were simple but pleasing. Some web sites showed their elegance with various multimedia and compatible colours.

- **Overall Functionality:** The overall functionality of the web sites was judged to be good. They were usable for the task intended.

### CULTURAL APPROPRIATENESS

![Cultural Dimensions](image)

**Legend**

- Uni
- Co-Uni 1
- Co-Uni 2
- Com
- School 1
- School 2

**Power Distance**

- Low: 0 1 2 3 4 5 6 7 8 9 10
- High

**Uncertainty Avoidance**

- Weak: 0 1 2 3 4 5 6 7 8 9 10
- Strong

**Individualism – Collectivism**

- Individualism: 0 1 2 3 4 5 6 7 8 9 10
- Collectivism

**Emotional orientation**

- Masculine: 0 1 2 3 4 5 6 7 8 9 10
- Feminine

**Long/Short-term orientation**

- Short Term: 0 1 2 3 4 5 6 7 8 9 10
- Long Term

**Overall Cultural Support**

- Insensitive: 0 1 2 3 4 5 6 8 9 10
- Respectful

**Note:** Thai National cultural characteristics tend to the right hand side of Figure 3.

- **Power Distance:** All web sites had a very high power distance by providing for passive learning. None allowed for any interaction while the lesson was going on. It shows the respect between the lecturer and the learners. The lecturer is the sole transmitter and the learner is the receiver.

- **Uncertainty Avoidance:** For all web sites the uncertainty avoidance was strong. The lecturer is the speaker and the learner is the listener. Thus, the learner shows obedience and politeness. There is little chance of a conflict or disagreement. Interestingly, the Com had been judged as the strongest uncertainty avoidance because the learners had to follow the contents very strictly in order to pass the course.

- **Individualism – Collectivism:** As with most e-learning, individualism is fundamental to the design. The learner learns alone with a computer. There are no face-to-face classmates. The lessons in the web sites themselves provide no interactive activities with a group, except within the classroom in the schools.

- **Emotional orientation:** The sites all tended to the feminine, as the goals and objectives have been set by the lecturer for the group rather than the learner choosing their own goals and content path. In this way the web sites were a reflection of traditional Thai classrooms.

- **Long/Short-term orientation:** For all web sites there was long term orientation. The structure and procedures were the same within each web site. The learner could continue their study with these web
sites after starting. The School 1 and 2 provided more short-term orientation than other web sites because those web sites were designed to support learning within the classroom.

- Overall Cultural Support: For all websites the overall cultural support tends to be respectful. The web sites will support the Thai culture at one stage e.g. the passive learning style, the high power distance and uncertainty avoidance, although learning via the web sites could separate the learners from society and could change the behaviour of the new generation.

CONCLUSIONS

All of the e-learning sites examined within the Uni, Co-Uni 1 and both schools were used for supplementary units/subjects in their courses/degree but the Co-Uni 1 also provided degree level for all learners outside of its university as well. There was more multimedia use such as sounds, video, animation in Uni and Co-Uni 1 than the schools. In terms of curriculum, Uni and Co-Uni 1 were very specific subject based while the schools were broader such as providing general knowledge related to curricula, e-books, examples of student work, and several subject tests (i.e. English, Science, Maths). The e-learning materials from Co-Uni 2, and Com were for adult students undertaking short courses at certificate level with a variety of multimedia such as video clip, sound, slide, zoom in-out, and animations. The Co-Uni 2 had accreditation for its certificates from government institutes, with government officials getting funding from their institutes for the learning certificate. Interestingly, it provided two types of learning: virtual classroom and classroom (appointment with teacher and roommate or workshop within a classroom). The Com sites advertising said that this web site did not mean to replace any classroom learning but was a supplement. It was the only web site that gave the user a choice of version to suit learners’ computers and internet access speed (e.g. 56 k no video but sound, and 64 k and 128 k has video). A computer readiness checklist was provided on the web sites of Uni, Co-Uni 1, Co-Uni 2 and they allowed the learners to download any required programmes or plug-ins they did not have.

As can be seen from the earlier figures (1, 2, 3), despite being designed independently and being intended for different courses and students, each of the e-learning sites scores very much the same. Partly this seems to be due to the underlying Learning Management systems all being fairly inflexible and limited in pedagogy and partly because Thai teaching and learning styles are similar irrespective of content or level.

In terms of interface design, all examined were very poor and seen not to have been designed with the mental model of the intended learner in mind. There was a general lack of consistency, an over use of graphics and animations, as well as little consideration given to learner control or individual differences. In many cases the screen design chosen seems to have little to do with the plan of instructional design and seems to have been chosen to showcase the cleverness of the programmer in achieving as many flashy icons, video clips, and sounds as possible.

The results of the Dimensions of Interactive Learning on the World Wide Web (WWW) show that the web sites focus on content and tend to guide learners in a style similar to the teacher centered approach in the classroom. Although they provide the ability for learners to go forward or backward, they do not provide learner opportunity to apply content or create their knowledge. The Interface Dimensions found that the web sites are easy to use and are quite manageable in terms of cognitive load. They have clear information and aesthetic screen designs but are quite poor in mapping and media integration. The results of Hofstede’s Cultural Dimensions show that most are suited to Thai behaviour such as, high power distance, high uncertainty avoidance, and low masculine [high feminine] except being high in individualism while Hofstede found that Thai people model high collectivism.

In summary, all web sites provided pedagogy for the learners with a familiar learning style, the interface was easy to use, and the design suited to Thai culture except the need to learn individually rather than within a group. Thus the web sites that were examined showed common traits that made them both appropriate in some ways and inappropriate in others. All of the e-learning sites examined followed instructivist pedagogy and this mirrors the pedagogy being used by many Thai teachers. Thus, Thai students should feel comfortable using materials of a similar pedagogy, lowering the cognitive load needed to use the materials at the possible expense of depth and application of knowledge. Culturally, the design web sites failed to enable that most Thai of learning attributes: group learning. However, in terms of underling pedagogy the web sites being the source of knowledge and the students being the recipients was appropriate. Also of concern was the level of computer literacy needed to use many of the materials (installing plug-ins etc) and the need to have access to technologies, such as high-end computers and high speed Internet, for some of the sites.

While this study took place in Thailand and was a small case study that should not be generalised, it does raise issues that go beyond the borders of any one country. While education is becoming a marketed commodity that is being sold globally (increasingly through e-learning), in reality that is a narrow definition of education. Education is very local and specific and e-learning design must reflect this if it is to be both effective and appropriate.
REFERENCES


ASSESSMENT THROUGH EXHIBITION: CONNECTING FOURTH YEAR PRIMARY/MIDDLE SCIENCE AND MATHEMATICS EDUCATION STUDENTS TO PLACE

Kathryn Paige
University of South Australia
Australia

ABSTRACT

Developing a sense of belonging to place has been a key theme for our undergraduate science and mathematics education courses for the past four years. It has been the basis of teaching and learning grants as we use the nexus between research and teaching to ensure our practice continues to evolve. This paper provides an historical background to how connection to place has become an essential component of the fourth year professional pathway. In the last three years final year education students with a passion for science have spent time in an ecological urban setting on a volunteer basis. This year the assessment strategy required them to use photo-story to construct a digital narrative of their experience. The importance of place, the impact place based experience has on the students final placement and the confidence gained by participating in assessment through exhibition are key aspects of this paper.

INTRODUCTION

In 2004 a Teaching and Learning Grant was used to investigate the importance of place by connecting fourth year education students to an urban ecological setting. The results from this trial have been used to incorporate place based education for final year students electing a science and mathematics professional pathway in the primary/middle program.

This paper will describe how the action research cycle has informed current practice in connecting education students to place. The data includes course materials, student journals and digital assignments. Benefits such as making professional links with a range of organizations and the ability to transfer skills and knowledge learnt in their transdisciplinary units of work for their final practicum or as beginning teachers will be explored.

This paper starts with an outline of the primary/middle program and the underpinning principles. This is followed by a literature review of the importance of place and assessment through exhibition. An outline of the research project completes this section. The paper concludes with a description of how place was featured in the 2007 student cohort and possible future directions.

CONTEXT

The relocation of the School of Education from the Underdale Campus to the Mawson Lakes Campus coupled with the implementation of new education programs, including the Bachelor of Education (Primary & Middle) that straddles two traditional levels of schooling, provided an opportunity to build on the innovative aspects of the R-7 program that had been taught at the Underdale Campus. As teachers working with students in Grades 3-9, will be working in a world today of changing circumstances that are particular as well as emerging, the Program Development Committee decided a good starting point was to identify and explore planning principles relevant to this age group and the times in which they live (Paige, Lloyd & Chartres, 2006; 2008). These are consistent with the Education Review Report (Reid & O’Donoghue, 2001) commissioned to give guidance to teacher education programmes at the University of South Australia (UniSA). The Bachelor of Education (Primary & Middle) program has as its aim, “to prepare educators who are professionally competent and primarily concerned with learners’ wellbeing and who are committed to social justice, futures thinking, sustainability, education for community living (place based), and sound pedagogical reasoning that is inquiry based”. These aims are the basis of the seven principles which relate to knowledge, understandings and dispositions associated with the learning environment, and it is these principles on which the program has been built. Education for Community Living (place-based education) is the principle that is the focus of this paper and explores how one course in the primary middle education program has provided opportunities for students to spend time in ecological urban settings.
An elective professional pathway in science, mathematics and society and environment for primary/middle students was implemented for the first time in 2006. The fourth year students in this course had the opportunity to participate in a place-based placement prior to undertaking their final five week teaching block. It is the experience of one aspect of this course that forms the basis of this paper.

LITERATURE REVIEW

This literature review focuses on two key aspects, firstly the importance of place and secondly, assessment through exhibition.

Making connections with the places we inhabit is an important component of well-being and a dimension of a transdisciplinary approach to teaching and learning. As Suzuki says “we ought to be greening the school yard, breaking up the asphalt and concrete… We have to give students hand lenses… lots of field trips… gardens in the school grounds etc. We have to reconnect these kids and we have to do it early… Our challenge is to reconnect children to their natural curiosity” (Suzuki & Vanderlinden, 2002, p. 9). Van Matre (1990) supports the importance of getting a feel for the environment and building a sense of ecological relationships through powerful emotional experiences in the field.

There is significant literature (Hawken, Lovins & Hunter, 1999; Lowe, 2006; Meadows, Randers & Meadows, 2004; Raskin et al., 2002; Suzuki, 2006), that suggests that we have to change the way we live, as the planet can no longer sustain our western way of life. Schumacher (1973) said we have to reject our current values of bigger, faster and more powerful higher production and wealth generation in favour of organic, gentle non-violent, the elegant and the beautiful (p. 662). There is also a growing education literature that suggests it is the responsibility of education to be part of the solution to world issues (Jucker, 2002; Roth & Desautels, 2002; Sterling, 2001). Gruenewald (2003) argues that the first point, re-developing a sense of place, has become a most revolutionary idea, because currently education is about standardising the educational experience of students from diverse cultural and geographical backgrounds so they can compete in the global economy reducing the importance of a student’s place in a primary experiential and educational context.

The importance of engagement is also raised in the literature. Hamilton & Dennis 2006 state that ‘the western world is in the grip of a consumption binge that is unique in human history. We aspire to lifestyles of the rich and famous at the cost of family, friends and personal fulfilment. Rates of stress, depression and obesity are up as we wrestle with emptiness and endless disappointments of consumer life (Hamilton & Dennis, 2006; Laszlo, 2003; Singer, 2006). Students retreat from public life and annual surveys suggest that they care less about the environment, racial understanding, community action programs or even discussing political issues (Loebe, 2001). Yet he sees less indifference and more learned helplessness- the feeling they can’t change the world so why try. So our experience is to encourage students in their last year to be involved in connecting with organisations involved in ‘hand ups, not hand outs’ (Souter, 2005) particularly in an ecologically sustainable context. There is a two way process where students develop a sense of place through contributing to the organization by providing curriculum input. We think this approach is a vital part of educating for sustainable futures. It is in way an example of what Loebe, 2001 says will help over come ‘broken connection” between firstly, values and action and secondly, between the world they inherit and the world they’ll pass on.

Saionji talks about restoring the ‘spirit of contentment’ in order to change the direction of our civilisation and seriously questions the ethics of building prosperity at the expense of others (Saionji, 2003, p. 42) This is a big ask but what we are attempting to do is motivate students to take on board some of these ideas and hopefully engage their students in meaningful learning experiences.

The importance of place can be traced back to Dewey (1915) and the discussion that human learning used to occur within specific locales but with the on set of the industrial revolution and the invention of schools this was removed. And as Smith (2002) reports ‘what happens in schools is different to what happens elsewhere, people experience the world directly.’ It is on this basis that we have included place based education as a 3-9 principle. We need to provide a wide range of experiences that allow students to connect what they are learning to their own lives, communities and regions (Smith 2002).

The characteristics/strengths of place based education include, its adaptability to the unique characteristics of particular places, an emphasis on learning experiences which allow students to become creators of knowledge, a central role to students’ questions and concerns, teachers acting as experienced co-learners and brokers of community resources, and overcoming the common disjuncture between school and children’s lives (Smith 2002a).

It is these characteristics the fourth year placement is attempting to address.
The second aspect of the literature review focuses on assessment and specifically, students using digital narratives to communicate their experience with place. Assessment through exhibition is a key middle school initiative and has been modelled in this undergraduate course. In 2007 communicating the experience became an example of authentic assessment. The students were asked to take photographs, interview someone in the organisation and in responding to set questions (appendix a) construct a report of key findings to share with peers all whom would be exiting teachers in the following month. The report in this instant was a digital narrative. The first task was to select up to ten key photographs and organise the sequence to best communicate to future beginning teachers how this organisation might be a helpful part of their educational network. Adding appropriate music and text through the use of photo story or imovie they constructed a three minute narrative.

The visual images chosen by the students do more than just illustrate the place (Banks, 2001) they also celebrate and document much of what is left unsaid about the significance of the place based experience and the impact it had on them as nearly graduating teachers. It captured their experience, their science learning, challenged and communicated their passion to make a positive difference. Lambert (2002) argues that the use of oral history and digital storytelling in particular, is a useful strategy to construct a personal sense of place, identity and history.

Groundwater-Smith, Mitchell and Mockler (2007) identify pedagogical practices that support student learning through providing opportunities to engage in a rich task. Central to the rich task is aligning curriculum, pedagogy and assessment. The place based experience and digital narrative as an assessment item support Groundwater – Smith, Mitchell & Mockler’s practices but in particular providing challenging and connected work and using technological tools for learning.

Shirley Brice Heath suggests that each ‘rich task’ project should be assessed in a ‘high-risk’ exhibition of some sort with students proceeding with a strong sense of purpose and persistence in doing projects, and in completing them at successful and satisfying levels (Brice-Heath 2007). Shirley Brice Heath’s primary research since 1987 has been with young people in under-resourced neighborhoods who learn entrepreneurial and community-building skills as they help create and sustain positive learning environments that contribute local cultural and economic resources. Her special interest in this work is documenting organizational structures and communication practices that surround everyday learning and progression in complex task achievement.

National Schools Network (2002) supports the public demonstration of student learning. It argues that it is the place where students are able to clearly describe to an audience, the deep understanding and knowledge they have obtained. It allows students to demonstrate their learning and provide the community with a real window into authentic learning. It was sharing this with others in their learning community that resulted in a very powerful experience. The digital narrative provides an opportunity for students to share the insights into their learning. As they construct their story they demonstrate the extent to which they have internalised the knowledge and reveals the depth and transfer of their conceptual understanding. It also supports an approach to learning which values student control and autonomy, helps build confidences to talk to a larger audience about their beliefs and practices and helps learners reflect on their strength and weaknesses.

But most of all the learning was supported, valued and celebrated. It allowed them to share their experiences and ideas with their colleagues rather than just one lecturer.

Feedback suggested that the course was challenging yet rewarding as one student in her course evaluation stated While the workload of this course was high it was a very practical and beneficial course. ....... The place based experience was also very valuable and gave us an opportunity to look at how we can use our communities in our future classrooms.

THE RESEARCH JOURNEY

This section describes each of three trials which have contributed to the 2007 version of place based learning experience.

Stage 1 2004 trial

The 2004 trial aimed to assist a group of fourth year education students to develop knowledge and skills in education for sustainability through the trialling of an innovative approach to teaching. The students taking part in this project were enrolled in a general studies sequence with a focus on ecological responsibility and sustainability. The project involved students’ experience in, and evaluation of, two key elements - work shadowing and mentoring. For this project, work shadowing involved the students participating in the work of community groups with an urban ecological focus. They developed their ability to work as professionals in communities, including schools, by being...
mentored by community group members who took an activist role towards sustaining and improving environmental and social parameters. Time was spent in different settings but it was towards the end of semester and quite rushed. The settings included Marine Discovery Centre, Global Education Centre, District Council and Urban Ecology Centre. They were asked to participate in the allocated tasks, contribute to the organization, as well as ask a range of questions that would assist beginning teachers to connect with the organization. Reflective journals were kept. Three of the six project students reported on their experiences in the project at a national environmental education conference held in Adelaide September 2004. Six months after the program was completed we found that of the 6 students two hadn’t completed the degree. Of the four finishers, one was teaching in a remote rural setting, one was a contract teacher in a complex city school, one was working in the Marine Discovery Centre, and the fourth working as musician. Having recently graduated teachers presenting at a national conference was well received. A voice that is often not there. They each gave a 15 minute reflection of the benefits to them as beginning teachers.

The beginning teachers identified two main benefits. Firstly, links to professional networks nationally and latest trends in ecological education. They suggested that their experience had encouraged them to make connections to their community, with one teacher using the field trip experiences as the basis for a planned 3 day field trip with his year R-3 class.

*At University we had been provided with diverse and constructive approaches to learning and investigating and I now find myself providing my students with these same opportunities. The mentoring model that we were a part of provided a different learning environment to the traditional classroom, and promoted the self-direction, experimentation and real world experience that I drew upon while organising and implementing week of environmental art and camp to Alice Springs. The contacts that we made during the course now provide a valuable bank of people, such as John, who I now feel I can call upon to help support my teaching and to provide my students with stimulating and productive ways of investigating their local and global environments. (Beginning teacher)*

Secondly, employability, with one getting paid work at the Marine Discovery Centre after volunteering for the first semester whilst waiting for her first appointment. The beginning teachers suggested that they needed longer amount of time over the entire semester to develop relationships with community persons & place and to complete the specific task(s) at placement. They also suggested that there needed to be more staff intervention to ensure better use of some placements.

It was this trial that impacted on the program committees decision to include place based education as one of the key principles underpinning the primary middle years program.

**Stage 2 2006 trial**

Having trialled it, the next phase was to explore the feasibility of implementing it in the professional pathways in the new program. 2006 was the first year in which there would be final year students in the program. As this cohort was in transition there were only 35 remaining which provided a situation that was conducive for trialling the practicalities of place based education. The idea of incorporating a place-based component was raised at a year level planning meeting. The science, mathematics and society and environment pathway made it a central part of their course’s requirements.

A group of 7 students were enrolled in the pathway. After reviewing the literature and setting up requirements for them to connect to a place it was up to their initiative to make the contact and set up what was possible. Two of the students had been accepted for honours and the remaining 5 were self directed motivated learners who were keen to maximise their last year at university.

They contacted a range of places that they were interested in and in some cases had to try a second. The organisations they spent time with were Marine Discovery Centre, Global Education Centre, Gawler Council, Snack& Chat and Botanic Gardens for World Environment Day.

The students experienced a range of challenges finding a location that they were keen to be connected to and that they had the time available to participate in a meaningful way. Having participated in a workshop that outlined the expectations, it became a self directed study each workshop the students reporting on their development. They were required to keep a record of their communication, Journals, email trails and pamphlets were all methods used. At the end of semester they were asked to summarise what has happened so far and to share what they found out about the organisation with the group. What we found was that some students were still involved and intended keeping it up throughout the year.
Some tasks
Students were involved in the following tasks
• after intensive workshadowing, running workstations on such topics as Fish identification and measuring chart, with an emphasis on characteristics and similarities/differences between species, with small groups of students at the Marine Discovery Centre
• developing a story line for a book for early years learners based on the concept of Interdependence /globalisation. The story titled ‘The world in my box’ was drafted and then the student headed off to the market to find goods from around the world. She found out that many toothbrushes are made in Germany and toothpaste is made in Spain. The items and book were to placed in an interactive classroom resource which could be lent out to schools.
• allocating food parcels to homeless families.

Reflective journal
Comments include
I leave a little wiser and a little disappointed that I could not be more use, still I know I did my best and certainly put in more time than I had initially anticipated. It would be an interesting place to work but a little dull, I think I need the stimulation of children to really excite me and make what I am doing seem worthwhile. It was all a little bit civilised for me. Karen

Stage 3 2007- The next iteration introducing assessment through exhibition
In 2007 there was a group of 8 students who took the science and mathematics option. Similar practice was embedded where the students initiated and set up appropriate placements to undertake their place based experience. What was different was the method of assessment. The students needed to construct a digital narrative of their experience and present it a final workshop session.

One student’s story
As part of our Professional Pathway, our final task was to become involved with a community organisation which we felt would support our learning as a pre-service teacher and beyond. As I am passionate about science and sustainability, I made inquiries with Trees for Life to see what options they had on offer. I would hardly call myself a green-thumb but decided on a challenge and signed up with a section of Trees for Life called Bush for Life, a group who relies heavily on volunteers to protect and maintain native bushland.

I attended a one day training session which completely changed my mindset about tackling weeds and it was a pleasant change to take on the role of student again, having my prior knowledge challenged and supported.

The benefits for me as a pre-service teacher are numerous. I have started to create my own collection of plant samples;  I have gained some techniques on how to destroy invading weeds and now that I have been allocated my own piece of bushland to care for right in the heart of suburbia, I have an outdoor classroom at my fingertips with an endless supply of resources and inspiration for some place-based learning.

By sharing my patch of bushland with students I feel as though I have the opportunity to model some simple ways in which they too can become passionate about science and the environment. Becoming involved with an organisation such as Trees for Life has enabled me to widen my access to resources and contacts that will be beneficial to me as a novice teacher

Stories about using digital narratives
Constructing and presenting their digital narratives was a highlight of the semester. Amy reflects below the impact the experience the learning had.

I found using the digital story allowed me to be creative in how I reflected my experience at the Marine Discovery Centre. It gave the opportunity to engage the class audibly and visually so they could really capture a sense of what my role was and what the Marine Discovery Centre has to offer. The use of a digital narrative allowed me to have a deeper impact on my peers through the photos and music I chose
rather than doing a presentation or writing an essay. Because we were only using photos and sentences/short paragraphs to convey our experience, I had to flesh out what was important to convey in my storyboard. I found watching my peers’ digital story boards was an enlightening experience. I could not only see the amount of effort that had gone into them but really gained a sense of their experiences. The only major hiccup I encountered was working out how to upload music and save it so all the photos would transfer. However it was great to play around with a new program and find out the benefits it could have in a classroom (Amy, recently graduating teacher)

WHERE TO FROM HERE

The journey in engaging fourth year undergraduate students with place and linking this to an assessment item provided an opportunity for students to participate in a rich learning task. The benefits for students are four fold, firstly they have all added to their knowledge of ecology secondly, they have developed a sense of belonging with a community and connected to a new place, thirdly, they have been introduced and used new technology software (photo-story) as an authentic assessment strategy and fourthly, they could see how they could access the organization as a beginning teacher. Truly a rich task.

The process continues to evolve as feedback is received and students excel in their contribution to the urban ecological centre to which they are connected. In 2007 many students continued to work long after the official university commitment ceased. Longitudinal research following up these students as beginning teachers would provide some useful information about the practical impact of the learning experience and how it is reflected in their classroom practice.

REFERENCES


Suter, K 2005 50 things you want to know about world issues..but were too afraid to ask. Australia, Bantam.


THE TWO CULTURES AND HIDDEN TRUTHS: A PERSONAL TRIBUTE

Bill Palmer
Associate, Curtin University of Technology
Australia

ABSTRACT

It is a long while since I first read C. P. Snow’s controversial book, *The two cultures*. At that stage of my life, I read anything which Snow wrote, particularly the fictional *Strangers and brothers* series, where academics and scientists plotted and schemed within institutions to gain positions of power and influence. There appeared to be similarities between the power struggles that Snow described in his books and the real events in the staff room at the school at which I was teaching, which gave personal relevance to his writing. More recently, my academic work centred on the problems involved in the teaching of science at a regional Australian university. The power struggles were still there, but were largely hidden from casual observation, so I have been reflecting lately on issues concerned with science culture, science history and the public understanding of science. One of those issues is whether there are two cultures (science and the arts) vehemently opposed to each other as Snow’s essay implies or whether time has mellowed that opposition. This study also describes Snow’s life and other issues raised in his essays but I primarily intend this study to be a tribute to a great man.

INTRODUCTION

As indicated in the abstract, I saw similarities between the power struggles that C. P. Snow described in the *Strangers and brothers* series and those I noted at my first teaching appointment. My own observations were limited to the more mundane interactions between the headmaster and the teaching staff in a British boarding grammar school, where I, as a very junior member of staff, observed the ill-tempered power struggles which were apparent at each staff meeting. Snow’s ideas of power were my means of interpreting and making sense of what I observed. As Gratzer (1990, p. 241) points out ‘C. P. Snow was fascinated by science and power’.

This study will reflect on the life and work of Charles Percy Snow in the light of this author’s gratitude for his wisdom. Some commentators undervalue Snow’s contributions and this issue will be considered later. Even if such a limited view of Snow were true, he still left us concepts and phrases that are of value, though perhaps simplistic. His views nearly fifty years later still act as catalysts for deeper discussion, itself a valuable legacy. This tribute will examine his life and his ideas, and also consider his concern for the poorer countries of the world, which tends to be omitted elsewhere.

C. P. SNOW’S FAMILY AND EARLY YEARS

Charles Percival Snow was born on 15th October, 1905. His father, William Edward Snow, was a qualified church organist (Fellow of the Royal College of Organists), but was unable to make a living from playing the organ, so he went where he could find employment; he became a clerk in a shoe factory in Leicester (Snow, 1982, pp. 2-3). He married Ada Sophia Robinson in 1897 at St James’s Church Aylestone Park, where he remained as organist and choirmaster for twenty years (Snow, 1982, pp. 2-3). The marriage produced four sons; Charles Percy Snow was the second son. A study of the family background shows C. P. Snow’s family had working class origins on his father’s side and a ‘submerged’ middle class status on his mother’s side. Table 1 provides in a little more detail about C. P. Snow’s life up to the time when he obtained his doctorate. He received all his education in Leicester in the British Midlands (Isaacs & Martin, 1985, p. 464), where he obtained a first class honours degree in Chemistry followed by a Masters degree in Physics in 1928.

At Alderman Newton’s School his duties as a laboratory assistant were evidently not very onerous. On one occasion, as his brother reports, the chemistry teacher reported that when Charles was asked to dismantle the equipment after a lesson, he simply swept it into a drawer by stretching his arms round the apparatus (Snow 1982, p. 24).
Table 1

Early Years

<table>
<thead>
<tr>
<th>Dates</th>
<th>Event</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1910-1916</td>
<td>Primary school: a private school, Beaumanor School, run by two spinster sisters with moderate fees, which were a struggle for the family. Charles benefited from this education and the local library. All the boys enjoyed backyard cricket.</td>
<td>Halperin, 1983, p. 8: Snow 1982, p. 10</td>
</tr>
<tr>
<td>1921</td>
<td>Popularity: Charles was popular with staff and his fellow students, was academically brilliant and a good cricketer (Captain of school team).</td>
<td>Snow, 1982, p. 15</td>
</tr>
<tr>
<td>1921</td>
<td>Charles’ Oxford Senior Local Examination results were excellent (8 subjects)</td>
<td>Snow, 1982, p. 17</td>
</tr>
<tr>
<td>1922</td>
<td>He was given the job of laboratory assistant at Alderman Newton’s school which gave him time to work for the British School Certificate (BSC) which was the next step to candidacy for the London University external degree. At that time the school had had no students progressing to university.</td>
<td>Halperin, 1983, p. 11</td>
</tr>
<tr>
<td>1925-1927</td>
<td>University: Charles obtained an Education Committee grant to go to University College, Leicester. He completed his first class London University external degree in chemistry in two years.</td>
<td>Halperin, 1983, p. 11</td>
</tr>
<tr>
<td>1927-1928</td>
<td>He obtained a research grant which enabled him to complete a masters degree in physics (infra-red spectroscopy) at University College, Leicester in one year.</td>
<td>Halperin, 1983, p. 11: Schusterman, 1975, p. 17</td>
</tr>
<tr>
<td>1928-1930</td>
<td>He was awarded a competitive Keddey-Fletcher-Warr scholarship to the value of £200 and was able to continue research, now at the Cavendish Laboratory, Cambridge.</td>
<td>Weintraub, 2004, p. 491: Halperin, 1983, p. 16</td>
</tr>
<tr>
<td>1930</td>
<td>He completed his doctorate entitled The infra-red spectra of simple diatomic molecules followed by a Fellowship at Christ’s College.</td>
<td>Weintraub, 2004, p. 491</td>
</tr>
<tr>
<td>1930</td>
<td>His career now continues as a College Fellow with tutorial responsibilities. He moved from research on infra-red spectra to crystallography.</td>
<td>Weintraub, 2004, p. 491</td>
</tr>
<tr>
<td>1932</td>
<td>He had his first novel Death under sail published, which he had written a few years earlier.</td>
<td>Schusterman, 1975, p. 21</td>
</tr>
</tbody>
</table>

Charles was said to be ‘completely hopeless’ on the practical side (Snow, 1982, p. 24). Philip also recounts an occasion when after a practical preparation of malachite green, not only were Charles’s hands coloured green but also his face and hair; Philip goes on to speculate that lack of practical ability was the real reason for Charles leaving research in the 1930s. Additionally Philip (p. 30) says that Charles was ‘quite unable to look after himself’ — throughout his life he never prepared a meal or part of one for himself or anyone else. While completing his first degree he became very thin perhaps caused by lack of nutrition and this became pernicious anaemia (p. 30). Of the same events, Charles Snow in his interviews with John Halperin brushed this off as ‘My nerves used to be pretty near the surface at that time, that’s all.’ (Halperin, 1983, p. 14)

As a general conclusion it may be stated that the family was close and loving, but frequently embattled by circumstances. In a class-conscious Britain, the family would be considered lower middle class. Charles’s brother, Philip (Snow, 1982, pp. 8-9) comments that the family had a lodger for many years who was a young female teacher, Lucy Parker, who fitted into the family well and relieved tension in times of stress, helping the younger boys with their homework.

Another interesting issue is whether Snow was a physicist or a chemist. Certainly he was a chemist up to the end of his first degree. With the topics researched for his doctorate and thereafter, he would generally be considered a physical chemist (Werskey, 1988, p. 24). Others, such as Bromberg (1982, p. 75), refer to him as a physicist. Although Snow seems to have considered himself a physicist but he does have some good things to say about
chemistry when he recollected learning about the periodic table (C.P. Snow, quoted URL: The periodic table of elements).

Snow earned a doctorate in physics at Cambridge in 1930; of his doctoral dissertation he said that it was ‘just some slapped-up papers to which you wrote an introduction’ (Halperin, 1983, p. 18). Evidently Snow ‘blew his career by a botched experiment and premature publication claiming the artificial synthesis of Vitamin A’ (Porter, 1996, p. 16). Gratzer (1990, p. 480) gives more detail in which he states that Snow’s conclusions were wholly wrong, no retraction was ever published and the author’s evasions were held to be unsatisfactory. Snow never published another academic paper.

**A DEVELOPING CAREER**

Table 2 indicates how C. P. Snow’s career developed as a scientist, a scientific administrator and a novelist.

<table>
<thead>
<tr>
<th>Dates</th>
<th>Event</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1934</td>
<td><em>The search</em> was published</td>
<td>Snow, 1982, p. 189</td>
</tr>
<tr>
<td>1937-1940</td>
<td>Charles became editor of <em>Discovery</em> with the first issue in April 1938.</td>
<td>Snow, 1982, pp. 50-51</td>
</tr>
<tr>
<td>1939</td>
<td>Charles was appointed to a sub-committee of the Royal Society to organise scientists for the war effort.</td>
<td>Schusterman, 1975, p. 13</td>
</tr>
<tr>
<td>1940</td>
<td>The first of the <em>Strangers and brothers</em> series was published. The original idea was conceived in 1935.</td>
<td>Snow, 1982, p. 189: Schusterman, 1975, p. 13</td>
</tr>
<tr>
<td>1940</td>
<td>In September, he joined the Ministry of Labour (MOL) (for 3 days a week) to recruit scientists for the war effort.</td>
<td>Snow, 1982, p. 189</td>
</tr>
<tr>
<td>1942</td>
<td>He was appointed Director of Technical Personnel, MOL.</td>
<td>Schusterman, 1975, p. 13</td>
</tr>
<tr>
<td>1944</td>
<td>He combined Government duties and Director of Scientific Personnel with the English Electric Company.</td>
<td>Schusterman, 1975, p. 13</td>
</tr>
<tr>
<td>1945-1960</td>
<td>He was appointed as a Civil Service Commissioner, kept up with writing the <em>Strangers and brothers</em> series and was appointed to the Board of the English Electric Company.</td>
<td>Schusterman, 1975, p. 13</td>
</tr>
<tr>
<td>1950</td>
<td>He married Pamela Hansford Johnson, a novelist, on 14 July.</td>
<td>Weintraub, 2004, p. 492</td>
</tr>
<tr>
<td>1952</td>
<td>They had one child, Philip Charles Hansford Snow (26 Aug).</td>
<td>Weintraub, 2004, p. 492</td>
</tr>
<tr>
<td>1957</td>
<td>They returned to London, so that they could both keep up with the literary scene.</td>
<td>Weintraub, 2004, p. 492</td>
</tr>
<tr>
<td>1959</td>
<td>Snow gave the Rede Lectures, <em>The two cultures and the scientific revolution</em>, which caused much controversy.</td>
<td>Weintraub, 2004, p. 492</td>
</tr>
<tr>
<td>1959</td>
<td>The Rede Lectures can be considered as the mid-point in Snow’s literary fiction. He wrote fourteen serious novels, (eleven novels in the <em>Strangers and brothers</em> series); seven were written before 1959 and seven after.</td>
<td>Graves, 1971, p. vii</td>
</tr>
<tr>
<td>1962</td>
<td>F. R. Leavis attacked the concept of <em>The two cultures</em> and also attacked Snow personally in his Richmond Lecture.</td>
<td>Cohen, 2001, p. 283: Greacen, 1962, p. 37</td>
</tr>
</tbody>
</table>
Snow moved his area of research from spectroscopy to crystallography, but he did not give a clear reason for this change in direction. The Director of the Cavendish Laboratory, Ernest Rutherford, did not like technology or industrial money (which he called mammon) (Werskey, 1988, p. 24), so money was always tight in the laboratory. Rutherford did not approve of spectroscopy (Halperin, 1983, p. 17), but neither did he like crystallography (Werskey, 1988, p. 81), which was the new field that Snow entered; Snow may have entered this field due to his friendship with J. D. Bernal, a brilliant crystallographer. Alternatively it may have been due to the problems with his spectrographic research referred to earlier. Certainly at this stage of his life he started to move out of practical scientific research.

He worked as a senior civil servant in the Ministry of Labour during World War II, staying in the civil service after the war in charge of technological recruitment (Isaacs & Martin, 1985, p. 464). Snow married the novelist Pamela Hansford Johnson in 1950. He managed to pursue a literary career writing his *Strangers and brothers* series, concurrently with his other responsibilities.

During the period labelled Snow’s middle years in Table 3, Charles Snow’s career moved steadily on from a research physical chemist to a Tutor of students at Christ’s College, Cambridge, to a senior civil servant and administrator during World War 2 writing increasingly successful novels every few years and then he was promoted to Harold Wilson's white-hot Ministry of Technology as Life Peer.

**SNOW’S ESTABLISHED CAREER AND ‘LAST THINGS’**

The final ten years of C. P. Snow’s life involved little that was different. It was nonetheless crowded with lecturing and academic travel almost continuously, though he was often in considerable pain from what he called lumbago, saying in 1979, ‘any kind of locomotion is hell’ (Snow, 1982, p. 180). C. P. Snow’s life has made an impact on science and literature; one very crude measure is that his name receives more entries (11) than anyone else connecting science and literature in *A literary companion to science* (Gratzer, 1990) though not all of these entries are favourable, with his friend H. G. Wells second with 10 entries. Table 3 covers the events towards the end of Snow’s life.

**Table 3**

<table>
<thead>
<tr>
<th>Dates</th>
<th>Event</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>He had eye surgery and suffered ‘cardiac arrest’. He was ‘dead’ for nearly four minutes. He said ‘I bring you no news from the other world.’ He remained ‘a pious unbeliever.’</td>
<td>Weintraub, 2004, p. 494: Halperin, 1983, p. 224</td>
</tr>
<tr>
<td>1970</td>
<td>The final novel <em>Last things</em> was published. The eleven books in the <em>Strangers and brothers</em> series ran to nearly two million words.</td>
<td>Weintraub, 2004, p. 494</td>
</tr>
<tr>
<td>1970-1980</td>
<td>He wrote three further novels and two biographical collections.</td>
<td>Weintraub, 2004, p. 494</td>
</tr>
<tr>
<td>1978</td>
<td>On his return from the USA, both he and Pamela had to be de-planed in wheelchairs, but he continued work.</td>
<td>Weintraub, 2004, p. 494</td>
</tr>
<tr>
<td>1980</td>
<td>He died from a perforated ulcer on 1 July.</td>
<td>Weintraub, 2004, p. 494</td>
</tr>
<tr>
<td>1980</td>
<td>His estate was valued at £312,000 gross.</td>
<td>Weintraub, 2004, p. 494</td>
</tr>
<tr>
<td>1981</td>
<td>Snow’s ashes were interred in the Fellow’s Garden at Christ’s College</td>
<td>Snow, 1982, p. 182</td>
</tr>
</tbody>
</table>
THE TWO CULTURES

Prior to the nineteenth century, an educated person needed to be familiar with all branches of knowledge. Later in Victorian England there was a move to teach only the classics. At the end of the nineteenth century the argument about the merits of a classical or a scientific education emerge (Cohen, 2001, p. 283) within the context of the public school system. T. H. Huxley's *Science and Culture*, lecture (Huxley, 1880) was delivered in Birmingham on October 1, 1880. Huxley's assertion was ‘...for the purpose of attaining real culture, an exclusively scientific education is at least as effectual as an exclusively literary education’ (Huxley, 1880). Arnold replied to this assertion in his Rede lecture of 1882 quoting ‘...but knowledge of morality will always console me for ignorance of physical science.’ (Arnold, 1882).

The phrase *The two cultures* was presented in 1959 as the title of one of the British Broadcasting Corporation’s annual *Rede Lectures* by C. P. Snow, though he had used the phrase in his writing three years earlier (in *The New Statesman*, 6 October, 1956). On this occasion it made a considerable impact. Perhaps it struck a chord in Britain because of the specialisation in secondary schools where most educated people had been forced to choose during their education between taking mainly science subjects or mainly arts subjects.

After giving the Rede Lectures in 1959, Snow’s views were attacked strongly by F. R. Leavis, a well-known and respected lecturer at Cambridge who had developed a distinctive style of literary criticism. Leavis retired in 1962 and later in that year ‘became embroiled in an infamous and ill-natured controversy’ with Snow (Isaacs & Martin, 1985, pp. 300-301), whilst critiquing Snow’s *Rede Lectures*. The attack was personal, bitter and very public; this attack on Snow was seen as unjust and may, in fact, have increased the acceptability of Snow’s views.

My aim here is to see if Snow’s essay, which was written more than forty years ago, has anything to say to us today. For example, did it predict any of the events that have taken place? Is the main thesis that we can divide human beings into two groups (those who study the humanities and those who study the sciences) valid? If this division can be made, is the notion that there is little communication between the two groups valid, now or in the past? Is the hypothetical lack of communication between the two groups harmful to societal harmony and progress?

Snow states his thesis most strongly below:

> Literary intellectuals at one pole — at the other scientists, and as the most representative, the physical scientists. Between the two a gulf of mutual incomprehension — sometimes (particularly among the young) hostility and dislike, but most of all lack of understanding. They have a curious distorted image of each other. (Snow, 1959, p. 4)

This image is further defined.

> The non-scientists have the rooted impression that the scientists are shallowly optimistic, unaware of man’s condition. On the other hand, the scientists believe that the literary intellectuals are totally lacking in foresight, peculiarly unconcerned with their brother men, in deep sense anti-intellectual, anxious to restrict both art and thought to the existential moment. (Snow, 1959, p. 5)

After the large amount of comment produced as a result of the initial lecture Snow (1969) modified and redefined a number of his strictures. Firstly his comments were to be considered as appropriate to the situation in England with which he was most familiar (p. 68); he explained the meaning of the word ‘culture’ in more detail; he changed the test for scientific understanding from knowing ‘the second law of thermodynamics’ to knowing enough bio-chemistry to make sense of Crick & Watson’s discovery of the structure of DNA (pp. 71-75); he discussed the question further of whether there are two cultures, three cultures or 2002 cultures (p. 73). C. P Snow in both his Rede Lectures (pp. 19-21) and in his *The two cultures and a second look* (p. 99) commented unfavourably on over-specialisation in the English educational system. Snow saw changing the educational system (pp. 99-100) as the solution to the problem of the lack of communication between scientists and non-scientists. His closing paragraph (p.100) predicted a future education in which a large proportion of those with better minds will have imaginative experiences in both the arts and science.
VIEWS OF SNOW’S CHARACTER AND ABILITY AS A NOVELIST

The main attack on Snow’s *The two cultures and the scientific revolution* and also on the *strangers and brothers* series came from F. R. Leavis ‘The two cultures exhibits an utter lack of intellectual distinction and an embarrassing vulgarity of style’ (Leavis, 1972, p. 44) and again:

> He can’t be said to know what a novel is. The nonentity is apparent on every page of his fictions—consistently manifested, whatever aspect of a novel one looks for. (Leavis, 1972, p. 45)

Some writers feel that Snow’s writing and ideas are shallow; for example, ‘He was the embodiment of a certain type of educated philistine: bluff, well-meaning, clubbable, so well-rounded as to be practically spherical’ (Kimball, 1994). Leavis was not the only person to disagree with Snow’s ‘two cultures’ theory. For example, Kimball gives an unfavourable view of the basis of Snow’s reputation repeating Leavis’s assertion that Snow was a ‘public relations man’ for science. (Kimball, 1994)

Many commentators are surprised at Leavis’s very bitter attack on C. P. Snow and this surprise is understandable, but Leavis’s intellectual position had been made clear over a long period of time but Moran (2002, p. 31) points out that ‘Leavis’s model of a broad-based education was implacably hostile to the sciences’. Snow’s writing and philosophy thus appeals to some and is an anathema to others. In the end each individual will make their own choice.

VIEWS OF C. P. SNOW AS A SCIENTIST

Snow is said to be a mouthpiece for science, but how good a scientist was he? Professor J. D. Bernal said of Snow:

> I worked with Snow at Cambridge in the most exciting year of 1932 when the neutron was discovered and *Scrutiny* was founded. He was a brilliant physical chemist whose work on photo-chemistry in the solid state could easily for him have opened up a new field of research.

(Bernal, 1962, quoted Greacen, 1962, p. 37)

In the same piece Bernal (Bernal, 1962, quoted Greacen, 1962, pp. 37-38) goes on to explain that what fascinated Snow ‘was the use to which science was put in government and industry. And he was not content to write about it. He lived and worked in it.’

De la Mothe (1992, p. 105) sees Snow as ‘a rather mediocre researcher and teacher in a profession where only brilliance counted …’. Snow’s evaluation of himself as a scientist (quoted Weintraub, 2004, p. 492) was not so very different ‘I should never have been much better than a goodish orthodox English professional — probably looking a bit better than I was because I’m bright.’ The incident of the flawed paper (mentioned earlier) with no retraction will make many wonder about his status as a scientist.

Falconer (1989, p. 106) writes about the Cavendish Laboratory in the time of J. J Thompson as Director as compared with Thompson’s predecessor and his successor who was Rutherford (the Director in Snow’s time at the Cavendish Laboratory). She points out that in Rutherford’s time a researcher had to be ‘a good glass-blower and handyman to construct apparatus.’ This does not sound like C. P Snow’s forte. Rutherford kept tight control over the finances so progress would be slow for anyone requiring expensive apparatus as might be needed in spectroscopy or microscopy. Perhaps this was an additional reason why Snow did not regret leaving practical research.

Stringer comes to the carefully argued conclusion that Snow is not to be trusted as an observer and commentator on the two cultures (Stringer, 1983, p.174). On the other hand, perhaps it is the authority with which Snow can speak as an observer, based on first-hand experience that makes his novels real to those with comparable experiences as expressed by Walsh (1963).

Snow’s experience as a scientist and civil servant and his talents as an observer and writer have made him probably the best-known and best-read authority on the closed politics of the university, the laboratory, and the upper reaches of the bureaucracy. (Walsh, 1963, p. 654)
A MODEL OF KNOWLEDGE

The way in which the two cultures debate is perceived depends to some extent on the model of knowledge with which the various parties to the debate operate. When less was known, it was perhaps easier to call one half of all knowledge ‘Arts’ and the other half ‘Science’, but as knowledge has increased, a simple dichotomous models has become more difficult to accept. Yet dichotomous models are popular, so much so that there is a Dictionary of contrasting pairs (Room, 1988). Examples, such as on the one hand, on the other hand; male, female; left, right; up, down; physical, chemical; conductors, insulators, et cetera are a common way of thinking, so that the Humanities/Science divide fits into that categorisation easily. Succinctly put the humanities are for reflection and the sciences for investigation (Reid and Traweek, 2000, p. 7).

Dichotomous models are not just a Western artefact, as in the Northern Territory, some local Aboriginal peoples group edible plants into two categories called ‘natha’ and ‘borum’. ‘Natha’ usually refers to plants which bear their produce under the ground and plants which belong to the category ‘borum’ usually produce their fruit above ground. (URL: Project atmosphere, 2007). Thus the two cultures theory was accepted by the general public for the following reasons.

- Because of the status and experience of the author.
- Because it was simple enough to be popularly accepted.
- Because it utilised an old theory of contrasting pairs which was easy to remember.
- Because there already was a divide between those who had studied the Arts and those who had studied the sciences, which was emphasised through the educational system.

There may be more fundamental reasons for an Arts/science divide and perhaps educational psychology can help.

CONTRARY IMAGINATIONS

Hudson (1966) in his book Contrary imaginations put forward the hypothesis that there were two natural modes of thought in his psychological study of the English schoolboy. These were said to be convergent thinking and divergent thinking. The majority of those who were convergent thinkers turned out to be studying science whilst the greater portion of those who were divergent thinkers turned out to be studying the Arts. The book offered an apparent explanation of Snow’s ‘two culture’ thesis. However this is all very mono-cultural. Not all countries make their 18-year-old students specialise to such a great extent as was the practice in England at that time. Entwistle sums what was known in the 1970s about subject choice and personality:

> There may also, as we have seen, be important personality differences which facilitate or inhibit a holist approach to learning. Subject areas may well both attract people with appropriate styles of thinking and develop those characteristic styles further. That was certainly C. P. Snow's view of the 'two cultures', …

(Entwistle, 1977, p. 236)

In general, the area was dormant until revived in a different form by Kolb who produced and validated a new Learning style inventory (Kolb, 2007), which is an assessment package which includes the converger/ diverger model with two added characteristics as opposites, assimilator/ accomodator. This four characteristic model has spawned a variety of new research in this area.

Thus, one reason why students might choose a science or an arts course could be their individual learning styles which could be genetically pre-programmed. That is, people are born convergers or divergers and so are destined to study the sciences or the arts. I suspect a hard view of a science/arts divide, such as this, is untenable, but the view, expressed in terms of a probability, that convergers might be more likely to become scientists is not unreasonable. However the hypothesis would be difficult to verify as it is often difficult to separate cause and effect.

CHOICE OF SCHOOL SUBJECTS: ANECDOTAL EVIDENCE

One change in the knowledge base is the rise of the use of computers since the 1990s which has opened up this whole new field of information technology, which can include aspects of science and art. New subjects make choices wider than in Snow’s youth. Computers, using the internet, provide a means for looking further into the ‘two cultures’ controversy. I was astounded to find how much has been written and how passionately the issue has been
discussed in recent years. It is now more than forty years since the well-known Rede lecture and a variety of commentators and critics are still giving their opinions. Some anecdotal examples of subject choice follow: Burnard (2000) referring to his own schooldays, has no regrets about his choice of Arts but does regret ‘being denied the study of chemistry’. Evidently those sixth forms who studied science were then referred to by the senior master as ‘beaker boilers’. Palmer (2003, p. 7) gave his account of the choice between science and the arts offered him:

At secondary school, when offered a choice of subject, I chose science, not from any natural predilection, but because I feared or disliked those teaching other possible subject choices more than those teaching science. (Palmer, 2003, p. 7)

Snow too, when asked if he had always had an interest in science, replied:

I never had any vocation, and very little interest, but it just seemed that this was the easiest way to carve something out. And then, why not? It came quite easily. I should never have been a good scientist, but I should have made a perfectly adequate one. (Halperin, 1983, p. 11)

Assertion and counter-assertion, stated as fact, has been made by teachers and educational leaders in England for more than a century, so it is hardly surprising that this topic remains fertile ground for continued debate.

SNOW’S OTHER WRITINGS AND VIEWS OF THIRD WORLD DEVELOPMENT

Snow, 1962 wrote a book Science and Government. This is a written version of his Godkin lectures about the personal antagonism during the Second World War between the two premier government science advisors, Sir Henry Tizard and F. A. Lindemann. This work caused much controversy. In this book, Snow told the story of disagreements between Sir Henry Tizard and F. A. Lindemann. Snow painted Lindemann, later Lord Cherwell, as a villain whilst treating Tizard far more favourably. Commentators express a variety of views, but often blame Snow for making the disagreement so public. Others such as Reid (1970) have been more even-handed in their treatment of both men.

A subsidiary dichotomy was put forward by Snow in both his Rede Lecture (pp.41-51) and in his revision of the lecture (pp. 79-86) — that is of the gap between the rich and poor in the world. Today this problem remains as described, probably even more intense than before. I thought one part of his argument particularly relevant to attitudes to peoples suffering poverty today. Snow sees that it is only through the application of science that their poverty may be alleviated.

CONCLUSION

Does the main thesis hold up to scrutiny today? Snow acknowledged that he was contrasting extreme positions, but he had observed these views at first hand as a celebrated novelist in touch with literary figures and also as a physical chemist and science administrator. The background against which Snow based his views was a narrow class based society, in which less than 5% of 18 year olds attended university. Schools traditionally gave greater kudos to students studying arts courses than to those studying the sciences and thus the ‘two cultures’ were an existing phenomenon at the time when Snow produced his analysis.

There has always been a spectrum of views and perhaps the extreme positions are as they have always been, but it would seem to me that the education on which he rested his hope for the future has increased the numbers of people in the middle of the spectrum. In England, it is no longer narrow elite that is educated; currently about 40% of the population goes on to university. In the USA, Australia and Europe percentages going on to university may well be in excess of this. Also the expansion of knowledge has led to new combinations within the sciences and within the arts and between them, forming new areas of knowledge for study. This has taken much of the heat out of the debate.

C. P. Snow died in 1980. It was his experience of both the worlds of science and of the worlds of the arts that allowed him to write and lecture about the different inhabitants of each world and it is this personal expertise that makes his views credible. C. P. Snow’s thoughts are still relevant today.
REFERENCES


The periodic table of elements, at URL http://www.aip.org/history/curie/periodic.htm (accessed on 1/1/08)
THE EFFECTIVENESS OF CONSTRUCTIVIST TEACHING ON IMPROVING LEARNING ENVIRONMENTS IN THAI SECONDARY SCHOOL SCIENCE CLASSROOMS

Panomporn Puacharearn
Rajabhat Nakhornsawan University
Thailand
Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

This paper describes the first study conducted in Thailand (2002-2003) that resulted in changes in science teachers’ classroom environments. In the first phase of the study, the Constructivist Learning Environment Survey (CLES), an instrument for assessing students’ perceptions of the actual and preferred classroom environment through the constructivist perspective, was validated for use in Thailand. Second, typical Thai secondary school science classroom environments were described using quantitative and qualitative methods. Finally, the effectiveness of constructivist teaching in promoting improvement in classroom environments was evaluated through an action research process, involving the use of feedback on actual and preferred classroom environments. The sample consisted of seven secondary science teachers and their 17 classes of 606 students in Nakhornsawan Province, Thailand. Student Actual and Preferred Forms of the CLES, assessing Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation, were administered. Factor analysis and internal consistency measures supported a five-factor structure for both Actual and Preferred Forms. Students’ attitudes to science were also measured. The actual and preferred environments of different classes were described based on profiles of classroom environment scores. A number of teachers then participated in an attempt to improve their classroom environments, through the use of a constructivist teaching approach. Changes in classrooms did occur, thus supporting the effectiveness of constructivist teaching in improving learning environments and students’ attitudes towards science in Thailand.

BACKGROUND

Today, the achievement of a positive classroom environment is a valuable goal for education (Fraser, 2002). The curriculum of schools and universities consists “not just of content and outcomes, but also of classrooms where the business of learning takes place” (Fraser, 2002, p. vii). At the global level, UNESCO has proposed its 2000 Project (Education Sector, UNESCO, 2003) to encourage countries around the world to provide science education for all people in order to let them have sufficient science knowledge to be able to live contentedly and safely in this age of globalization.

Similar to the UNESCO’s goal, is a statement in section 81 of the Thai National Constitution B.E. 2540, on the role of science, which states that; “The government must pay great attention to developing science and technology in order to develop the country” (p. 23). To reach such a goal requires strong development in science education.

In addition, the latest Thai National Education Act of B.E. 2542 (1999, p. 12) section 22 states that:

Education shall be based on the principle that all learners are capable of learning and self-development, and are regarded as being most important. The teaching-learning process shall aim at enabling the learners to develop themselves at their own pace and to the best of their potential.

Furthermore, some parts of section 23 go on to note that Thai science education needs to focus on scientific and technological knowledge and skills, as well as knowledge, understanding and experience in management, conservation, and utilization of national resources and the environment, in a balanced and sustainable manner.

Although teaching and learning in Thailand, particularly in science classrooms, tries to follow the above important principles, there are still problems. The low quality of provided education is one of the current critical problems in Thailand. Actual practices in classrooms have been dominated by teacher-centered and lecture-type instruction. One significant research study of the Thai Ministry of Education has shown that Thai students at grade 12 can pass only one of eight subjects in the examination with a score of more than 50% (Ministry of Education, 416)
So, it can be said that the quality of education in the upper secondary school level is not good and should be improved, particularly in science and mathematics.

In order to overcome this critical problem, recent national education reform movements in Thailand have been grounded in a constructivist approach to learning. That is, students should find personal relevance in their studies, share control over their learning, feel free to express concerns about their learning, view science as ever changing, and interact with each other to improve comprehension (Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1997).

Constructivism has become a leading theoretical position in education and has become a powerful driving force in science education (Steffe & Gale, 1995; Tobin, 1993). The appeal of constructivism is that it provides a plausible, functional framework for understanding and interpreting experiences of learning and teaching. In this way, constructivism acts as a powerful theoretical referent “to build a classroom that maximizes student learning” (Tobin & Tippins, 1993, p. 7). Furthermore, constructivism also has had a strong impact, internationally, on the educational field for over 20 years. In particular, science educators have been concerned with teaching strategies based on the notions of constructivism in an attempt to enhance students' conceptual understanding in science subjects. In many cases, these notions have been utilised as basic frameworks to reform traditional educational practices.

Fraser (1989) noted that students spend a great amount of time (more than 15,000 hours) in the classroom environment. Therefore, he argued that the quality of the environment of these classrooms has a significant impact on students’ learning. Classroom environments involve the shared perceptions of the students and teachers in a particular environment (Fraser, 1986). Although the concept of classroom environment is subtle, much progress has been made in conceptualising, measuring and analysing it, and mapping its effects on students (Fraser, 1986, 1994, 1998a, 1998b). Studies have indicated that students’ perceptions of their classroom learning environments affect students’ cognitive and affective outcomes (Fraser, 1986, 1989, 1994; Fraser & Fisher, 1982; Walberg, 1976). Also, students have been found to achieve better in the types of classroom environments which they prefer (Fraser & Fisher, 1983a, 1983b).

The practical implication of the findings is that class achievement of certain outcomes might be enhanced by attempting to change the actual classroom environment in ways, which make it more congruent with that preferred by the class. This study used the student actual and preferred forms of the CLES to assess the science classroom environment.

The Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & Fisher, 1997) was developed based on constructivist learning principles to investigate students’ perceptions of their learning environments from constructivist views and to assist teachers to reshape their teaching practice. Initially, Taylor (1991) constructed this instrument based on social and personal notions of constructivism whose main concerns are to enhance students’ conceptual understanding. Through an extensive and rigorous process, this version was found to be valid and reliable for use within classroom situations. However, the developers concluded that this version did not include some important points. Therefore, they elaborated and revised the CLES by adding notions of radical constructivism and critical theory (Taylor, Fraser, & Fisher 1997). This new version was thought to be useable with a wide range of samples, including different subjects and year levels and has five six-item scales, namely, Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. This 25-item version was used in the present study.

Two forms of the CLES, the Student Actual and Student Preferred (Taylor, Dawson, & Fraser, 1995), were adopted to gather students’ perceptions of science classrooms. Although item wording is almost identical in the Actual and Preferred Forms, words such as ‘I wish’ were included in the Preferred Form to remind students that they were rating their preferred or ideal classroom, rather than the actual classroom environment. For example, the statement, “In this class, I learn about the world outside of school” in the Actual Form of the CLES is changed in the Preferred Form to, “In this class, I wish that I learned about the world outside of school”.

This study is timely and valuable due to the importance of constructivist teaching in influencing classroom environments. It also adds needed research data on constructivist teaching and its influence on students’ perceptions of their classroom learning environments in Thai upper secondary school science classrooms. Because of the critical needs in Thai education to develop science teaching and learning in all schools, especially at the upper secondary level, this research is also useful for showing ways in which teachers can use constructivist teaching to improve classroom environments in the hope of facilitating improved students’ academic achievement.
Aim and objectives of the study

The overall aim of this research study was to determine whether teachers can use constructivist teaching through an action research process in order to improve their classroom environments. This study attempted to answer the following four research questions:

1. What are students' perceptions of their actual and preferred learning environments from a constructivist perspective?
2. Are teachers able to make use of learners’ responses to the CLES to improve their own classroom learning environments?
3. Does constructivist teaching improve students’ attitudes towards science learning activities and self-efficacy?

METHODOLOGY

Research design

Following a check of the validation of the CLES in Thailand, this study was divided into two phases, namely, its use in describing science classroom environments in Thailand, and the effectiveness of constructivist teaching on improving classroom environments. Two questionnaires were chosen for use in this research study. The first one was the Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & Fisher, 1997) used for investigating students’ perceptions of their learning environments through constructivist views. The second one was an Attitude Questionnaire consisting of two scales. One scale was the Attitude to Science Learning Activities (Kim, Fisher, & Fraser, 1999) and the second scale was Self-Efficacy (Jinks & Morgan, 1999). All instruments were translated from the English version into a Thai version for use in science classes in Thailand, following a back-translation procedure.

Phase One

The Actual and Preferred Forms of the CLES in the Thai version were administered to the above sample in order to obtain a general image of Thai secondary school science classes. The collected data were used to determine what are students’ perceptions of their actual and preferred learning environments from a constructivist perspective. Furthermore, scale scores in the form of the class average student scores on the Actual and Preferred Forms of the CLES were tabulated and reported to each teacher in a graphic format. These charts showed comparisons of student actual and preferred environments.

Phase Two

This phase involved answering the second and third research questions whether teachers could make use of learners’ responses to the CLES to improve their own classroom learning environments and whether constructivist teaching can improve students’ attitudes towards science learning activities and self-efficacy. At the same time as they responded to the two versions of the CLES, students responded to the Attitude Questionnaire to assess their learning outcomes on the attitude dimension.

Three case-study teachers were invited to improve their classroom environments. Each of these female teachers chose one of her classes that she believed needed a better classroom environment. Based on the results obtained from the Actual and Preferred Forms of the CLES, each teacher developed an action plan in an attempt to alter her own classroom environment. The teachers agreed to follow the methodology for promoting change used in prior learning environment studies (Fraser & Fisher, 1986; Sinclair & Fraser, 2001; Yarrow, Millwater, & Fraser, 1997) that involved:

1. assessing the students’ actual and preferred classroom environments;
2. providing the results to the teacher and assisting the teacher in making action plans to improve teacher’s own classroom environment;
3. collecting qualitative data from students about the class, activities and the teacher;
4. holding weekly individual meetings with the teacher concerning class occurrences and specific techniques that could be used in an attempt to change the actual environment; and
5. re-assessing the students’ actual environments.
Each teacher selected an area of specific concern, based on the differences between the scale means of the students’ actual and preferred scores from the CLES, and the discussion with the researcher, to design a plan of action for improvement. The researcher visited each class about once a week during the semester prior to the post-test at the end of the semester, in order to assist the teachers in implementing constructivist teaching in their classrooms. All students completed the Student Actual Form of the CLES as a post-test. The results were analysed by the researcher who presented them to each teacher privately for discussion and possible explanations. Students also were asked to complete the Attitude Questionnaire as a pre-test during the fourth week of the school term, and as a post-test two weeks before the end of the school term.

RESULTS

Description of science classroom environment in Thailand

The results (see Figure 1) suggest that the average classroom in this study had relatively high levels of student perceived actual Uncertainty (3.28), Student Negotiation (3.01), and Personal Relevance (2.90), but the levels of Shared Control (2.01) and Critical Voice (2.20) were consistently lower. When students’ actual and preferred perceptions were compared, there was a statistically significant difference between the students’ actual and preferred environments on all five scales ($p < .001$).

![Figure 1](image)

Figure 1. Thai secondary school science students’ average actual and preferred classroom environments for the whole sample ($N=606$).

Effectiveness of constructivist teaching on improving learning environments

Changes in the classrooms of the three teachers did occur, thus supporting the effectiveness of constructivist teaching in improving learning environments and students’ attitudes towards science in Thailand.

The statistical data of pretest and posttest mean scores indicated that in all three case studies, constructivist teaching could improve students’ attitudes towards their science learning activities and academic self-efficacy. It was noteworthy that the level of students’ attitudes before and after learning with constructivist teaching had changed from Sometimes to Often on the Attitude to Science Learning Activities scale in the classes of Teachers A and C, but remained at the same level of Often in Teacher B’s class. On the Self-efficacy scale, there was a change from Seldom to Sometimes in only Teacher C’s class, but remained at the same level of Seldom and Sometimes in the classes of Teachers A and B.
Because of the space limitations, only one of the three case studies is reported in detail here.

**Case study for Teacher B**

*Pretest and Posttest Results for Teacher B’s Class*

![Graph showing pretest and posttest results for Teacher B's class](image)

*Figure 2.* Preferred, actual pretest and actual posttest scores of Teacher B’s students \( (n = 39) \).

*Attitude for Teacher B’s Class*

![Bar chart showing changes in attitudes](image)

*Figure 3.* Changes in Attitudes of Teacher B’s students towards Science Learning Activities and Self-Efficacy after learning with constructivist teaching \( (n = 39) \).
Figure 2 shows that improvement occurred in the students’ perceived environments between the pretest and posttest on the two dimensions (Critical Voice and Shared Control) on which changes were attempted. For the Critical Voice and Shared Control scales, the change was 0.96 and 0.86 in the scale means. The scales, which were not targeted by the teacher for improvement namely, Personal Relevance, Uncertainty and Student Negotiation also showed improvements of 0.60, 0.23 and 0.94, respectively. It is noteworthy that in the class of Teacher B, as shown by Figure 3, the level of students’ attitudes increased on the mean scores in both scales and was statistically significant ($p<.001$). The mean score of Attitude to Science Learning Activities scale changed from 3.73 to 4.30 where as the Self-Efficacy mean changed from 2.56 to 3.08.

**CONCLUSION**

The CLES questionnaire which has proved to be valid and reliable of for use in Thailand could be used by Thai science teachers and researchers to conduct further investigation leading to improvements in science classroom environments and consequently students’ achievement in science. Moreover, it was found that the CLES took little class time to administer and could be quickly hand-scored. It is also possible to design and use a CLES score sheet which can be scored via the computer. The CLES is easily accessible, inexpensive, reliable, and easy to score and interpret making it of considerable value to classroom teachers.

It is also noteworthy that students perceived that their science classes Sometimes and Seldom reflected constructivist aspects, with the average item mean ranging from 2.01-3.28 (a mean of 3 and 2 corresponds to Sometimes and Seldom. The mean score of Personal Relevance, Uncertainty and Student Negotiation is close to 3.0, which suggest that the learning environment in science classrooms of Thailand emphasises relevance to everyday life, inquiry-centred learning, and student negotiation. In the case of Shared Control and Critical Voice students perceived that their science lessons are slightly more than Seldom but close to 2 in both cases. This suggests that Thai students perceived that their teachers were not sharing aspects of learning science with their students and students do not often express their thoughts and criticisms about their learning and how it might be improved. They also suggested that social interactions have an effect on the classroom environment, but that this positive effect is not great enough to change traditional science classrooms into highly constructivist-oriented ones. The finding implies that Thailand needs more teacher development programs, particularly those regarding teachers’ readiness to implement a new science curriculum based on constructivist principles, for improving science learning environments.

The findings confirmed that teachers are able to make use of learners’ responses to the CLES to improve their own classroom learning environments. Therefore, teachers who receive support and training can consider students’ views about their classrooms and improve their classroom environments. Consequently, teachers can develop and apply their own plans to induce classroom environment changes based on their students’ actual and preferred CLES results. The CLES results can remain confidential or teachers are able to compare their results with other teachers or educators in an attempt to receive professional opinions concerning ways to change what they are dong. After a desirable time, the teachers can reassess their environments with the CLES and compare the information with that in the previous assessment to see if their applied methods do improve their classroom environment.

**REFERENCES**


CREATING A NETWORKING PROCESS AMONG UNIVERSITY STAFF, SUPERVISORS AND SCHOOLS FOR IMPROVING INSERVICE TEACHERS’ COMPETENCIES

Panomporn Puacharearn
Rajabhat Nakhornsawan University
Thailand
and
Darrell Fisher
Curtin University of Technology
Australia

ABSTRACT

This paper describes a networking process conducted in Thailand (2006) that resulted in changes in teachers’ competencies to improve their classroom environments using a constructivist perspective. First, with the cooperation of university staff, educational-area supervisors and principals, research teams were constructed. Secondly, a networking process was developed for implementing in schools, and finally the attitudes of teachers about this process were assessed. The process involved three steps: forming teams in schools; working with teachers to improve teachers’ competencies in teaching; and setting opportunities for teachers to present their own action research about improving student learning. There were three parts to step two of this process. These involved: training teachers on instructional innovation (relevance to school needs ensured); training teachers on how to implement instructional innovation in their classes through action research; and holding weekly individual meetings with the teachers concerning class occurrences and specific techniques that could be used in an attempt to improve student learning. All 23 teachers from three case-study schools successfully implemented instructional innovation in their classes through action research. Teachers’ attitudes toward the networking process activities and perceptions of self efficacy were changed in a positive direction following use of the networking activities. These results suggest that the networking process in this research was effective in improving inservice-teachers competencies in teaching.

BACKGROUND

Although a number of research studies confirm the importance of teachers’ roles in developing student learning, in small schools in Thailand the lack of teachers’ competencies in teaching is identified as a key factor of low quality of students’ learning. Education communities, especially universities, have the responsibility to address this problem because academic service to the community is one of the important missions of all universities.

A whole school approach is an effective and innovative approach to school development. It has been shown that key success factors of improving teachers’ competencies in teaching are principals, teachers, core steering teams in schools, and academic leaders in community or from universities because synergy of power between inside and outside school can improve inservice-teachers’ competencies. Participatory action research influences teachers to be able to systematically implement instructional innovation in their classes.

Recent national education reform movements in Thailand have been grounded in a constructivist approach to learning. That is, students should find personal relevance in their studies, share control over their learning, feel free to express concerns about their learning, view science as ever changing, and interact with each other to improve comprehension (Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1997).

Constructivism has become a leading theoretical position in education and has become a powerful driving force in science education (Steffe & Gale, 1995; Tobin, 1993). The appeal of constructivism is that it provides a plausible, functional framework for understanding and interpreting experiences of learning and teaching. In this way, constructivism acts as a powerful theoretical referent “to build a classroom that maximizes student learning” (Tobin & Tippins, 1993, p. 7). Furthermore, constructivism also has had a strong impact, internationally, on the educational field for over 20 years. In particular, science educators have been concerned with teaching strategies based on the notions of constructivism in an attempt to enhance students' conceptual understanding in science subjects. In many cases, these notions have been utilised as basic frameworks to reform traditional educational practices.
Studies describing psychosocial learning environments have involved numerous factors that influence learning in classrooms. Research specifically on classroom learning environments commenced with the separate works of Walberg (Anderson & Walberg, 1968; Walberg, 1979) and Moos (1974). These two works have spawned many diverse research programs around the world (Fraser, 1994, 1998a). Although earlier work often used questionnaires to assess learning environments, the productive combination of qualitative and quantitative methods is a hallmark of the field today (Tobin & Fraser, 1998).

The Constructivist Learning Environment Survey (CLES) was developed to provide a plausible perspective of teachers’ attempts to transform their classroom learning environments in accordance with the critical constructivist epistemology (Taylor, Dawson & Fraser, 1995). The CLES was developed in 1991 (Taylor & Fraser, 1991) to enable teachers to monitor the transformation from a more teacher-centered approach to a more constructivist teaching approaches and to address key restraints to the development of constructivist classroom climates in school science and mathematics (Taylor, Fraser & Fisher, 1997).

The CLES assesses learners’ and teachers’ perceptions of five dimensions pertinent to the notion of constructivist, namely: Personal Relevance (the extent to which teachers relate science and mathematics to learners’ out-of-school experiences), Uncertainty (the extent to which opportunities are provided for the learners to experience mathematics and science knowledge as arising from theory dependent inquiry, involving human experience and values, evolving and non-foundational, and culturally and socially determined), Shared Control (the extent to which learners are invited to share with the teacher’s control of the learning environment, including the articulation of their own learning goals, design and management of their learning activities with the determination and application of assessment criteria), Student Negotiation (the extent to which opportunities exist for learners to explain and justify to other learners their newly developing ideas and to listen and reflect on the viability of other learners’ ideas) and Critical Voice (the extent to which a social climate has been established in which learners feel that it is legitimate and beneficial to question the teacher’s pedagogical plans and methods and to express concerns about any implements to their learning.

The CLES is available in an actual and preferred form (Kim, Fisher & Fraser, 1999). As with the development of preferred forms related to other learning environment instruments (Fraser, 1994, 1998), the CLES preferred form is concerned with goal and value orientation and measures the learners perceptions of the learning environment that learners would ideally like. Past studies that have made use of the CLES have found the instrument’s to be robust and consistently reports high reliability.

This study is timely and valuable due to the importance of constructivist teaching in influencing classroom environments. It also adds needed research data on constructivist teaching and its influence on students’ perceptions of their classroom learning environments in Thai school science classrooms. Because of the critical needs in Thai education to develop science teaching and learning in all schools, especially in small schools, this research is also useful for showing ways in which teachers can use constructivist teaching to improve classroom environments in the hope of facilitating improved students’ academic achievement.

**METHODOLOGY**

**Aim and objectives of the study**

The overall aim of this research study was to create a networking process for improving inservice-teachers competencies in teaching to improve their classroom environments using a constructivist perspective. This study attempted to answer these questions:
1. What type of networking process can be created among university staff, supervisors and schools for improving inservice-teachers competencies in teaching?
2. Are teachers able to make use of learners’ responses to the CLES to improve their own classroom learning environments after participation in such a networking process?
3. Does a networking process among university staff, supervisors and schools improve teachers’ attitudes toward the activities involved in such a process and their perceptions of their self-efficacy?

**Research design**

This study was divided into two phases. Twenty three teachers with their principals from three small schools, 3 supervisors from the area Office of Education Area and 2 university staff worked cooperatively to improve teachers’ competencies in teaching. The duration of the study was nearly one year from July 2006-December 2006. The methodology used to answer the research questions was a multi-method approach utilizing both quantitative and
qualitative approaches. Three measures were employed to obtain an understanding of teachers’ competencies in teaching: survey, interviews, and observations. The questionnaires provided quantitative data to answer the research questions. The quantity and quality of the teachers’ action research were used to evaluate the effectiveness of the networking process. Teacher interviews were then used in order to explain and clarify the quantitative data. The research involved the following two phases.

**Phase One:** This phase involved constructing a networking process among university staff, supervisors and schools for improving inservice-teachers competencies in teaching. A research team was formed that developed a networking process among university staff, supervisors and schools for improving inservice-teachers competencies in teaching.

The networking process was constructed among university staff, supervisors and schools and first involved forming a team in each school. The roles for the various team members are described in Table 1.

Table 1
**Key Roles of Team Members in the Process**

<table>
<thead>
<tr>
<th>Principals</th>
<th>University staff</th>
<th>Supervisors</th>
<th>Teachers</th>
</tr>
</thead>
<tbody>
<tr>
<td>-empower teacher to improve their teaching -organize team work in school -focus on participatory management -plan to coach and support teachers in areas relevant to their needs -give positive feedback to teachers</td>
<td>-establish good relationship with schools -implement effective curriculum and workshop for teachers to improve their teaching -develop a strategic plan to work with schools and supervisors</td>
<td>-visit schools to see teachers’ problems in teaching -provide relevant support for teachers in need -share ideas and difficult problems with principals, university staff to reach for consensus of difficult problems</td>
<td>-ask for coaching from inside and outside school (colleague, supervisor or university staff). -share ideas with others in the process</td>
</tr>
</tbody>
</table>

Thus, the teams worked with the teachers in attempts to enhance their competencies. This involved educating teachers on instructional innovations relevant to their school needs; and training teachers on how to implement instructional innovation in their classes through action research.

**Phase Two:** In this phase the process was evaluated. A group of teachers’ action research in three case-study schools, their attitudes toward networking process activities (assessed both before and after the process) and their perceptions of their self-efficacy were used to indicate whether the networking process was effective in bringing about improvement in teaching. During this phase, weekly meetings were held with individual teachers concerning class occurrences and specific techniques that could be used in an attempt to improve student learning.

Finally, opportunities were provided for teachers to present their own action research about improving student learning.

The actual process used in this study involved teachers’ focusing on improving their own classroom environments through a constructivist perspective. A two day training workshop was provided on constructivist teaching approaches and how to use the CLES to improve classroom environments. To implement constructivist teaching approach in classrooms, teachers followed these steps.

1. The students’ actual and preferred classroom environments were assessed with the Constructivist Learning Environment Survey.
2. The teachers shared the results with the supervisor and constructed action plans to improve their own classroom environments.
3. Qualitative data were collected from students about the class and learning activities.
4. The students’ perceptions of their actual classroom environments were re-assessed.
5. A one-day workshop was provided for the teachers on how to write a research proposal and action research reports.
6. Finally, a one day meeting for all 23 teachers was provided in order for them to present their own action research results and share ideas with other participants.
RESULTS

All 23 teachers from the three case-study schools were successful in completing the action research on improving constructivist learning environments in their classrooms. Teachers’ attitudes towards a networking process activities and self efficacy were changed positively after using the networking activities. These two results can be used to indicate that the networking process in this research was effective to improving inservice-teachers competencies in teaching. Because of time and space limitations, only one of the case studies is reported in detail here.

Case Study for Teacher A

Pretest and Posttest Results for Teacher A’s Class

Differences among preferred and actual pretest scores, and actual posttest scores of Teacher A’s students (n = 18).

Scores for the attitudes of the teachers and their perceptions of their self efficacy were accumulated and are presented in the following figure for each of the three schools.

CONCLUSIONS

Universities and Offices of Basic Education should use this networking process to improve teachers’ competencies and should encourage university staff and principals to join in the process. The Office of Research and Development
of the University and the Dean of Faculty of Education should encourage staff to research on implementing various instructional innovations in different subjects at kindergarten, elementary and secondary levels through the networking process.

It may be possible to successfully implement constructivist teaching approaches and the CLES in classrooms if there is a more coordinated effort among universities including Rajabhat Universities, school teachers, schools and the community. Universities should have the capability to train preservice and inservice teachers in the use of constructivist teaching approaches consistent with the CLES and the model for improving the classroom learning environment and students’ learning outcomes. Also, with the teachers’ own willingness and support given by the school and supervisors from Office of Basic Education Area, it is hoped that teachers will use a constructivist teaching approach and the CLES to improve their classroom environment, students’ academic and attitude outcomes.

The findings confirmed that teachers are able to make use of learners’ responses to the CLES to improve their own classroom learning environments. Therefore, teachers who receive support and training can consider students’ views about their classrooms and improve their classroom environments. Consequently, teachers can develop and apply their own plans to induce classroom environment changes based on their students’ actual and preferred CLES results. The CLES results can remain confidential or teachers are able to compare their results with other teachers or educators in an attempt to receive professional opinions concerning ways to change what they are doing. After a desirable time, the teachers can reassess their environments with the CLES and compare the information with that in the previous assessment to see if their applied methods do improve their classroom environment.

REFERENCES

A STUDY OF SCIENCE LEARNING ACHIEVEMENT OF PRATHOMSUKSA 3 STUDENTS IN HYDROLOGIC CYCLE USING CLOUDING AND RAINING DEMONSTRATION ACCESSORIES

Patcharin Sripaisaan  
St. Mary’s School, Thailand  
Chutima Intarapanich  
Udon Thani Rajabhat University, Thailand

ABSTRACT

This study looked at learning achievement of 182 nine and ten-year-old female students studying the Hydrologic Cycle, with some of the using the Clouding and Raining Demonstration Accessories (CRDA) compared to other students who did not. The subjects of this study were 182 students, in four Science classes at St. Mary’s School during 2006. The study found that using the CRDA resulted in higher student achievement.

Keywords: science, hydrologic cycle, cloud, rain, demonstration

HYDROLOGIC CYCLE BRIEF DESCRIPTION

Water is a chemical substance found on Earth for billions of years. It currently covers over 70% of Earth's surface and is a key basis for biological life. Water can exist in three different forms: solid, liquid, and gas. It can move between these states depending on its energy content. (The Foundation for Water and Energy Education, 2008) One way of studying water is to classify it by location in the environment: surface, underground, or atmospheric.

Surface water is visible and flows in natural and manmade water courses, such as rivers, lakes, reservoirs, and oceans. Besides these, surface water exists in its solid state as snow and ice at the polar ice caps and in mountain snow and glaciers.

Groundwater is water found beneath the Earth's surface. It comes mainly from rain, which soaks into the ground and flows downward through sand and gravel until it reaches a point where the ground is not permeable. At this point it flows laterally or collects in large underground bodies called aquifers.

Humans access groundwater in some areas by drilling wells in the ground to access aquifers. In other places water can be accessed from “springs”, which is when underground pressure forces groundwater to the Earth’s surface. This kind of water resource is sometimes produced by the geothermal energy from the earth's crust, especially near fault lines in the Earth’s crust where magma comes close to the surface. In these cases the water is heated, resulting in a ‘hot spring.’

Atmospheric water is water in its gaseous form, which may be called steam, clouds, or fog. Liquid water becomes a gas when it is exposed to sunlight and warm temperatures. The water absorbs energy and some of the water molecules vibrate faster. The most excited water molecules fly off into the atmosphere as steam.

Figure 1: Hydrologic Cycle
When water changes to vapor, it is difficult to see with the naked eye. The vapor is light weight and rises upward into the sky until it reaches the troposphere, where approximately 99.99% of it is contained. (Wikipedia, 2007) At that elevation the water vapor begins to condense as billions of droplets or crystals to form clouds.

There are many kinds of clouds, including the nimbostratus cloud (a low altitude cloud which can produce steady moderate to heavy precipitation) or tower cumulus cloud (a cloud with great vertical height that may cause lightning, thunder, and hail). These kinds of clouds have low temperatures. When they are saturated, they drop in elevation. At lower altitudes water vapor in the clouds condenses when the cloud meets cool temperature and falls to the earth as different types of precipitation such as rain, hail, and snow. (Learning Module on Earth Science and Astronomy, 2006) Much of the water becomes runoff that goes into reservoirs, streams and rivers as it flows back to the ocean or is absorbed in the ground. Some of the ground water is also absorbed by plant roots. The plants then release water to the air through their leaves.

The Foundation for Water and Energy Education (2008) describes how the hydrologic cycle works on its website, saying “Some of the precipitation will be absorbed into the ground. This is called infiltration. Once in the ground, the water can join the earth's groundwater supply. This is one of the world's largest storehouses of water.” This constant movement of water from ground to surface to air and back again has continued for billions of years and is called the “Hydrologic Cycle.”

To provide 9 year-old students with the information above, the teacher/researcher used pictures and experimental activities. Students were motivated to do the learning activities. The learning outcome for the students matched the study objectives: they could record experimental results, reach some conclusions about the experiment, explain the experimental result and answer related questions.

However, most students did not fully grasp the links between stages of the Hydrologic Cycle. Nor could they explain exactly how water had transitioned between the stages within the cycle. When they had an achievement test, the score was ‘fair.’ It indicated their learning was very specific to aspects of the experiment and lecture, but they could not yet apply it to their daily life.

Since B.E. 2544 (A.D. 2001), Thailand’s Basic Education Curriculum has stated that learning of science should be a developmental process which leads students to knowledge construction and should be a life-long process enabling them to apply science learning to their daily and professional life. The students should also be able to accumulate data and analyze results to find answers for questions, making decision based on reasonable use of data and finally, communicating their questions, answers, data and discoveries from their learning to others. (The Institute for the Promotion of Teaching Science and Technology, 2007) To reach this goal, they needed learning cooperation, self-practice and various types of investigation from local and non-local learning sources. These benefit their knowledge construction in the future and develop an attitude of life-long learning, scientific ethics, and help them see the value in science.

This Basic Education Curriculum goal inspired this researcher to assemble a demonstration kit to try to deepen student understanding of stages of the Hydrologic Cycle and movement between them. With the assistance of Mr. Anuchat Intarapanich, mechanic and inventor, a set of cloud and rain demonstrations were created and named Clouding and Raining Demonstration Accessories (CRDA). This study describes how this demo kit was used with St. Mary’s School Prathomsuksa 3 (Grade 3) Science students to make actual clouds and rain for their experiments.

**RESEARCH QUESTION**

Does the CRDA in Science class help increase the students’ learning achievement about the Hydrologic Cycle?

**OBJECTIVE**

To compare learning achievement between Prathomsuksa 3 students who studied the Hydrologic Cycle with and without the CRDA.

**METHODOLOGY**

The experimental approach consists of the following steps:

Step 1  Find content
Gather the Hydrologic Cycle Science content from various sources. Revise it to be appropriate for this age group, Prathomsuksa 3.

**Step 2  Create research tools**

Research tools created for this study included a lesson plan, practice worksheets, an achievement test, questions, and the CRDA.

**Step 3  Collect data**

To collect data, students (experimental group) do activities defined in the lesson plan—research tools are used in this step. When the experiment completes, students are assigned to summarize, discuss the result of activities, and then do the achievement test. Research data was collected by observation, questioning the students, and recording scores from practice worksheets and the achievement test.

**Step 4  Analyze data**

Data collected from practice, questions, and achievement test in Step 3 are compared to the collected data of students (control group) who studied Hydrologic Cycle without CRDA in semester 2 academic year 2005. In this step, the average achievement test scores of the experimental group who studied with CRDA were compared to those average test scores of the control group.

**Step 5  Reach conclusions and report results**

**POPULATION AND SAMPLE**

The target group in this study is Prathomsuksa 3 students (Grade 3) of St. Mary’s School in Muang, Udon Thani Province in Thailand. This school is the second largest girls’ school in Udon Thani, with 2,398 students in 56 classes and curricula for K-1 to Mathayomsuksa 6 (Grade 12). There are 118 teachers of many different subjects and most have a Bachelor’s Degree. It is located near downtown with easy access and educational services. Students come from a wide range of socio-economic backgrounds. The sample of the study was 182 Prathomsuksa 3 students from 4 science classes in semester 2 of academic year 2006.

**FINDINGS**

Figure 2-4 below shows science learning achievement for students using and not using the CRDA while learning about the Hydrologic Cycle.

**Figure 2: Average achievement test scores of the experimental group in 2006**

From figure 1, the highest average achievement test scores from Class 3/4 were 27.57 while the lowest Class 3/3 had an average score of 26.27.

**Figure 3: A comparison of average test scores of the experimental group in 2006 and the control group in 2005.**
From figure 3, we see the average achievement test scores of the experimental group who studied the Hydrologic Cycle with CRDA in 2006 and the control group who studied the same content in 2005 without the CRDA were compared class by class. The findings show that the average scores of the 4 classes in the experimental group are higher than those in the control group.

Figure 4: An overall comparison of average test scores of the experimental group in 2006 and the control group in 2005

Figure 4 shows that the overall average achievement test scores of the experimental group, who studied Hydrologic Cycle with the CRDA in 2006, are higher than those of the control group, who studied without the CRDA in 2005. In fact, as you will note in figure 4, the experimental group’s average score of 26.96 is 89.87% of complete mastery of the material whereas the control group’s average score of 23.21 is only 77.36% of completely mastering the material. Based on the differences between the control and experimental groups’ scores, we see that using the CRDA increased student learning achievement by 12.51%.

CONCLUSION

The research results show that students who studied the Hydrologic Cycle with the CRDA can better explain the stages of water movement in the Hydrologic Cycle and are better able to apply this knowledge in their studies of related scientific areas. They could answer teacher’s questions and do learning activity worksheets. Experimental group students had 12.51% higher average achievement test scores when compared to students who studied without the CRDA in 2005. Hence, we conclude that using the CRDA measurably improved science teaching effectiveness and student mastery of the Hydrologic Cycle concepts.

DISCUSSION

When using the CRDA, a cloud and rain maker, in science classes, students in the experimental group had higher participation in the experiment; they observed, investigated, and experimented themselves. Acting like scientists offered them chances to see all processes of the circulation of water from its liquid form, saw it evaporate, and finally saw it condense and precipitate back to its liquid form.

There were three main advantages to using the CRDA. First, the students were stimulated. That’s because the CRDA was new to them. Second, many questions were asked by the students since they saw the changing stages of water in the demonstration process. Finally, after the experiment most students were able to explain the transition of water between all its stages and explain the relation between each part of the CRDA and Hydrologic Cycle stages.

When watching students in the experimental group, it was obvious that they were better able to make links between their experimentally gained Hydrologic Cycle knowledge and their daily experience.

However, the result of this study has shown limits of the CRDA. Based on our experience, we suggested having several sets of the CRDA. One reason for needing spare sets of the CDRA is because running the condensation experiment repeatedly during the day made the condenser bottles too warm. In a single CRDA, the condenser bottle did not have time to cool down between experiments. As a result of the different temperatures of the condenser bottles, the experimental results the students got differed slightly during the day. This affected the recording, conclusion and explanation by the students. It also suggested that the CRDA kits should be provided
to small groups of students. This would allow hands-on experimentation by more students, which is better than only having the students watch the teacher do the experiments.

REFERENCES


EFFECTS OF PROVIDING ACTIVITIES BASED ON INCREASING EFFICACY OF FORAGES FOR DAIRY COWS OF SMALL HOLDER FARMERS AT UDON THANI, THAILAND

Montha Phuedam
Udon Thani Rajabhat University, Thailand.

Abstract

This study reports the effects of “Providing Activities Based on Increasing Efficiency of Forages for Dairy Cows” of smallholder farmers at Udon Thani, Thailand and to analyze their attitudes regarding raising of dairy cows. The sample subjects were forty-two farmers from Sreetat district and Thungfon district who completely attended the activities. They were selected by the cluster random sampling technique. The ability achievement was determined by a comparison of pre-test scores to post-test scores. Reliability of the achievement test was .7355. The attitudes were surveyed by a rating-scale questionnaire after post-test. The results indicated that the average scores of the post-test were significantly higher than the scores of the pretest at the .01 level. Moreover the farmers have a “High” level of satisfaction toward raising dairy cows. The findings revealed that the activities based on increasing efficiency of forages for dairy cows have a positive effect on raising of dairy cows. It may be a result of the efficiency of the activities which focuses on the process and sequential and systematic improvement of raising skills of dairy cows.

Keywords : Forages, Dairy Cows, Raising Ability Achievement, Small Holder Farmers.

Introduction

The vision of Thailand’s future as seen by scholars various fields, is of a society undergoing continual and rapid changes. Improving living standards for the people in the rural areas is an essential part of the government’s policy. Education now aims to maintain a balance of expertise and social development based on four criteria: education for all, education with equal opportunities, life long education and education for work. The strategy to solve the rural problems may be spelled out as follows: to create, most importantly, the condition of self-sufficiency to the local people, to create the sense of cooperation and eagerness for self development and the community; to consider the problem and the environment in each specific area in order to find the most suitable methods to solve the problem with the most fruitful outcome; to employ the most simple and economic means to solve the problem by utilizing local materials. To achieve these goals a new direction in education will emphasize the following: the creation of a teaching and learning network between families and educational institutes as well as the development of education in communities and society. In this way, people will be able to select the knowledge appropriate to their lives and needs (Phuedam, 1997).

Dairy raising for milk production in Udon Thani, the northeast of Thailand is expanding rapidly. There are four dairy cooperatives. Failure or success of this activity depends on reproductive performance, milk production and economic return. It should be noted that this region is poorly endowed with natural resources, there is erratically which may effect performance of dairy cattle in general and more specifically on reproduction. A crucial problem of small holder farmers is cows without ovarian activity, then cows without estrus, pregnancy, parturition and milking. Insufficient feeding management may be one of the caused (Phuedam, 1992). Dairy production will continue to expand in Thailand and to produce milk at an economic price, without subsidies, forage production must increase accordingly. The major constraint to increase livestock production is the difficulty of providing forages of sufficient quantity and with adequate nutrients throughout the year. Increasing, expensive concentrates have to be fed to animals. Often these concentrates are fed ad libitum and can represent 60% of the dairy farmers’ direct costs. It has been shown that dairy farmers can achieve a highly economic return from cows fed pasture only, provided that the pasture is properly managed, is leafy and of a high quality. Thai farmers will achieve greater profit on improved pasture as their main source of feed and reduce their dependence on expensive concentrates (Hare, M.D., 1995).

Hence the researcher decided to develop a research on the effects of providing activities based on increasing efficiency of forages for dairy cows of small holder farmers at Udon Thani.

Objective

The research was to study the effects of “Providing Activities Based on Increasing Efficiency of Forages for Dairy Cows” of smallholder farmers and their attitudes toward raising dairy cows at Udon Thani, Thailand.
Research Methodology

Research Design

This is an experimental study. The research design of this study is one group pretest post-test design model by Borg et al. (1989).

Population

The population consisted of smallholder farmers at Udon Thani province who raised dairy cows. There were four dairy cooperatives such as Muang district, Sreetat district, Kudjob district and Thungfon district. The sample subjects were forty-two farmers from Sreetat district and Thungfon district who completely attended the activities. They were selected by the cluster random sampling technique.

Research Instruments

The research instruments were consisted of an achievement test (pretest, post-test) and a set of questionnaires on attitude towards raising dairy cows. The content validity of the achievement test was checked by three provincial husbandry extension officers who often taught farmers and by three dairy small holder farmers who raised dairy cows. There were three levels of cognitive ability on the test. There were knowledge, understanding and application. The reliability of the achievement test was determined by trying out the instrument with 30 dairy small holder farmers who raised dairy cows in a rural setting similar to the actual target villages of this study. This was to ensure that the questions were clear, unambiguous, not confusing, and the language was easily understood to dairy farmers and no problems. The reliability of the test was 0.7355 by using the Kuder-Richardson formula (KR-21). The content validity and reliability of the attitude test were determined by using the same procedures as those employed for the achievement test (Borg et al., 1989).

Data Collection

Preparation

1. Coordination with the cooperatives in Udon Thani province such as Muang, Sreetat, Kudjob and Thungfon.
2. Meeting with the organizations, including the personnel who are involved, to describe the project.
3. Selection of the farmers who will be in the training.

The operation

1. Coordination for the meetings.
2. The training was conducted in these areas: Maung district, Sreetat district, Kudjob district and Thungfon district. The curriculum for training included:
   - Factors that affect the quantity and the components of milk.
   - The influence of the proportion between forage and other nutritional feeding materials.
   - The importance of forage toward the ruminants.
   - Producing the energy, protein and vitamins in the cows from eating the good quality of forage.
   - Management of the forage in diary cow farms.
   - Using local feeding resources such as rice straw, corn, cassava, sugar cane etc.
   - Development of groups to produce plants for feeding the cattle.

   Examples: Raising the pasture grasses for sale; producing grasses for fermentation in plastic bags and plastic tanks; producing hays; using EM(Effective Microorganism) and molass dissolved in water then pour this mixture over the rice straw etc.
3. The training was conducted in three phases, during March-June 2005.
   - The first training phase of training was conducted in a pasture in Napipuan village, Paco sub district, Maung district, Nongkai province and in the feed development station of Nongkai province. We provided the bus to take the farmers from each of the four cooperatives to visit the pasture in Nongkai province for one day.
   - The second training phase was conducted for one day at each dairy cooperative.
   - The third phase was carried pangola grasses for planting at the small holder farmers’ farm.
4. Data were collected from the small holder farmers at Sreetat district and Thungfon district. Before the implementation of the activities they took pretest on the achievement test. At the end of the experiment, the achievement test and the attitude test were administered to the experimental group as well.
**Data Analysis**

Data analysis consisted of the results of the achievement test and questionnaires on their attitudes toward raising dairy cows. The arithmetic mean was used to provide the average scores of pretest and post-test for the experimental group. The standard deviation was used to show the variation of scores. The t-test was used to determine whether there was any significant difference between the achievement of pretest scores and post-test scores. And the Kuder-Richardson formula(KR-21) was determined by SPSS to ascertain the reliability of the achievement test (Borg et al., 1989).

**Results and Discussion**

The results of this research were as follows:

**Table 1** Comparison between the pretest and post-test on small holder farmers’ achievement.

<table>
<thead>
<tr>
<th>Score</th>
<th>n</th>
<th>X</th>
<th>S.D.</th>
<th>t-test</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>42</td>
<td>12.90</td>
<td>2.84</td>
<td>-6.474**</td>
<td>.000</td>
</tr>
<tr>
<td>Post-test</td>
<td>42</td>
<td>16.52</td>
<td>2.25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**highly significant differences at .01 level**

As shown in table 1, all forty two farmers took a pretest and post-test of the achievement test. The average score of pretest and post-test was 12.90 and 16.52 respectively. It found that the post-test score was higher significantly difference than the pretest score at .01 level.

**Table 2** Shows the attitude of the farmers toward raising dairy cows.

<table>
<thead>
<tr>
<th>No.</th>
<th>Note</th>
<th>X</th>
<th>S.D.</th>
<th>Effected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>I enjoy raising dairy cows.</td>
<td>2.57</td>
<td>.50</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>I think it is valuable to be able to solve the problems of raising dairy cows by myself.</td>
<td>2.62</td>
<td>.58</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>I think my way of raising dairy cows is inferior to other people.</td>
<td>2.07</td>
<td>.48</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>I think and plan carefully before starting to work with anything.</td>
<td>2.55</td>
<td>.53</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Even when I am disappointed with the results, I continue to work and don’t lose hope.</td>
<td>2.90</td>
<td>.30</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>I think that having goals challenges us to get to know what we want, what we have to do, and what will be the results if our work is successful.</td>
<td>2.70</td>
<td>.46</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>I believe that to utilize your time efficiently you need to establish clear goals and have specific objectives.</td>
<td>2.55</td>
<td>.59</td>
<td>High</td>
</tr>
<tr>
<td>8</td>
<td>I always compliment other people when I see they are doing well.</td>
<td>2.63</td>
<td>.55</td>
<td>High</td>
</tr>
<tr>
<td>9</td>
<td>I believe that obstacles and problems in our life help us to change and to find better answers.</td>
<td>2.60</td>
<td>.56</td>
<td>High</td>
</tr>
<tr>
<td>10</td>
<td>I can expresses my feelings, beliefs or complaints to other people without any conflict.</td>
<td>2.28</td>
<td>.64</td>
<td>Medium</td>
</tr>
</tbody>
</table>
11. I am comfortable among different types of people. 2.43 .50 Medium
12. I feel it is difficult to build relationships with other people. 2.10 .66 Medium
13. I can find the way to solve problems when work in groups. 2.32 .54 Medium
14. When I fail I will think of new methods, and work until it is successful. 2.67 .48 High
15. I am working hard to achieve rather than because I am afraid to fail. 2.77 .53 High

From the results given in table 2, the farmers have a “High” level of satisfaction toward raising dairy cows in the following areas: the farmers enjoy raising dairy cows; I think it is valuable to be able to solve the problems of raising dairy cows by myself; I think and plan carefully before starting to work with anything; even when I am disappointed with the results, I continue to work and don’t lose hope; I think that having goals challenges us to get to know what we want, what we have to do, and what will be the results if our work is successful; I believe that to utilize your time efficiently you need to establish clear goals and have specific objectives; I always compliment other people when I see they are doing well; I believe that obstacles and problems in our life help us to change and to find better answers; when I fail I will think of new methods, and work until it is successful, and; I am working hard to achieve rather than because I am afraid to fail.

Conclusions and Recommendation

The study has shown the achievement of the small holder farmers before and after providing activities based on increasing the efficiency of forages for dairy cows was significantly difference at the .01 level. Moreover the farmers have a “High” level of satisfaction toward raising dairy cows. The findings revealed that the activities based on increasing efficiency of forages for dairy cows have a positive effect on raising of dairy cows. It may be a result of the efficiency of the activities which focuses on the process and sequential and systematic improvement of raising skills of dairy cows. However, further studies should be conducted using local grasses, legumes and waste products for dairy cows.

Acknowledgement

The authors are grateful for the financial support from the Clinic Technology of the Ministry of Science and Technology, Thailand to carry out this providing activities for increasing efficiency of forages for dairy cows of small holder farmers at Udon Thani, Thailand.

References

ABSTRACT

This paper presents the findings from research in Australian Junior Science classrooms that utilized the Questionnaire on Teacher Interaction (QTI) and the Students’ Motivation, Attitude and Self-Efficacy in Science (SMASES) questionnaire. It will highlight students’ perceived levels of teacher interpersonal behaviour and examine to what extent teacher interpersonal behaviour influences student motivation. Not only does teacher interpersonal behaviour have a direct effect on student motivation, but it can also determine high quality and valuable learning. Three aspects of student motivation are statistically analysed in relation to teacher interpersonal behaviour in this paper: achievement goal, student learning and performance goals.

INTRODUCTION

The focus in this paper is to present an overview of the impact that teacher interpersonal behaviour has on students’ motivation in science classrooms. Learning experiences in the classroom that initiate motivation may differ from those that sustain it. It is recognized that motivation is an essential tool for enhancing classroom learning. The importance that teacher interpersonal behaviour plays in influencing the responsiveness of students to set tasks cannot be underestimated. Motivated students possess a desire to learn and invariably to achieve. The level of motivation adopted by students, may be determined by the manner in which scientific concepts are delivered to them. Wubbels and Levy (1993) asserted that effective teaching involves a methodical or organisational element, but more importantly relies on interpersonal actions that create and maintain a positive classroom atmosphere.

The Questionnaire on Teacher Interaction (QTI)

Much of the work accomplished on teacher interpersonal behaviour stemmed from research that began in The Netherlands in the 1970s. The focus of the Education for Teachers project was to target beginning teachers and identify the problems they experienced, with the intention of providing better pre-service opportunities for teachers. In 1985, Wubbels, Créton, and Hooymayers developed a model of interpersonal behaviour (see Figure 1) that was developed from Leary’s (1957) work that initiated the construction of the instrument The Questionnaire on Teacher Interaction (QTI) to gather information about perceptions about teacher-student interactions (Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1993). The Questionnaire on Teacher Interaction (QTI) 48-item economical version developed in Australia (Wubbels, 1993) was used in this study and a scale description is provided in Table 1.

The original version of the QTI that was developed in the early 1980s in the Netherlands had 77-items (Wubbels, Créton, & Hooymayers, 1985). An American version was developed that contained 64-items (Wubbels & Levy, 1991) confirmed the cross-cultural validity and usefulness of the QTI. Wubbels and Levy (1991) reported acceptable internal consistency reliabilities for the QTI scales ranging from 0.76 to 0.84 for student responses and from 0.74 to 0.84 for teacher responses. Several studies on the reliability and validity of the QTI have been implemented (Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006) and in an American sample (Wubbels & Levy, 1989). Thus, the QTI can reliably present feedback to teachers about their interpersonal behaviour on the basis of class means.
<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Leadership</td>
<td>Extent to which the teacher provides leadership to the class and holds student attention</td>
<td>This teacher explains things clearly.</td>
</tr>
<tr>
<td>CD Helping/ Friendly</td>
<td>Extent to which the teacher is friendly and helpful towards students</td>
<td>This teacher is friendly.</td>
</tr>
<tr>
<td>CS Understanding</td>
<td>Extent to which the teacher shows understanding and care to students</td>
<td>If we don’t agree with this teacher, we can talk about it.</td>
</tr>
<tr>
<td>SC Student Responsibility/ Freedom</td>
<td>Extent to which the students are given opportunities to assume responsibilities for their own activities</td>
<td>We can influence this teacher.</td>
</tr>
<tr>
<td>SO Uncertain</td>
<td>Extent to which the teacher exhibits her/his uncertainty</td>
<td>This teacher seems uncertain.</td>
</tr>
<tr>
<td>OS Dissatisfied</td>
<td>Extent to which the teacher shows unhappiness/dissatisfaction with the students</td>
<td>This teacher thinks that we know nothing.</td>
</tr>
<tr>
<td>OD Admonishing</td>
<td>Extent to which the teacher shows anger/temper and is impatient in class</td>
<td>This teacher gets angry.</td>
</tr>
<tr>
<td>DO Strict</td>
<td>Extent to which the teacher is strict with demands of the students</td>
<td>We are afraid of this teacher.</td>
</tr>
</tbody>
</table>

Figure 1. The Model of Teacher Interpersonal Behaviour.
Previous uses of the QTI in Australia

Initially in Australia, the QTI was utilized in a study that investigated associations between school learning environment and teacher interpersonal behaviour (Fisher, Fraser, & Wubbels, 1993; Fisher, Fraser, Wubbels, & Brekelmans, 1993). The investigation was conducted in seven schools in Western Australia and Tasmania. The total number of students who completed the QTI was 792. The major finding in this study was that there was a weak relationship between the QTI and the School Level Environment Questionnaire (SLEQ) scores and that a teacher’s behaviour in class has little impact on how one perceives the school environment. Fisher, Henderson, and Fraser (1995) completed a study in Tasmania using the QTI for the first time in senior high school biology classes. The study successfully revealed cross-validation for the QTI when used in biology classes. The Cronbach alpha reliability figures for different QTI scales ranged from 0.63 to 0.83 for individual student analysis, and from 0.74 to 0.95 when the class mean was the unit of analysis. Results confirmed the internal consistency of the QTI and were similar to results reported in the USA (Wubbels & Levy, 1991).

Students’ motivation toward science learning

The 32-item SMASES that was used in this study was formed by adapting relevant sections of the Students’ Motivation Towards Science Learning (SMTSL) (Tuan, Chin, & Shieh, 2005) to measure student motivation (14 items); the Attitudes Towards Science scale (10 items) based on the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981) that measured students’ enjoyment of science; and an academic self-efficacy scale (8 items) taken from an instrument called the Attitude and Efficacy Questionnaire (AEQ) (Fisher, Aldridge, Fraser, & Wood, 2001). All three instruments had high internal consistency and proved to be valid for use in this research. The combination of aspects of the SMTSL, TOSRA and the AEQ and an extensive review of their past uses, secured the need to devise the SMASES. Fourteen questions assessed three aspects of motivation, Science Learning Value, Performance Goals and Achievement Goals. Table 2 provides a description of each scale and a sample item from the SMASES.

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science Learning Value</td>
<td>The importance of science in learning</td>
<td>I think that learning science is important because I use it in my everyday life.</td>
</tr>
<tr>
<td>Performance Goal</td>
<td>Reason for participating in science classes</td>
<td>I participate in science to get a good grade.</td>
</tr>
<tr>
<td>Achievement Goal</td>
<td>Explaining student fulfillment in science classes</td>
<td>During a science course I feel most fulfilled when the teacher accepts my ideas.</td>
</tr>
</tbody>
</table>

METHODOLOGY

The purpose of this study was to investigate teacher interpersonal behaviour and its effect on student motivation in science. The research was conducted in a private girls’ college in Brisbane, Australia, where the researcher was employed. The school’s population was approximately 520 students who were of varying socio-economic background. The study entailed collecting data from 313 students from the 12 classes of junior (year levels 8, 9 and 10) science, that is, the classes of five female science teachers including the researcher’s classes. Students who answered the questionnaires were studying various topics in science, including anatomy and physiology, earth science, chemistry and physics units. Both questionnaires, the QTI and the SMASES were designed so that the students answered the questions directly on to the answer sheet and in close proximity to the question. Students responded to the QTI on a scale from 0 to 4 (Never to Always) and to the SMASES on a scale ranging from 5 (Strongly Agree) to 1 (Strongly Disagree).

RESULTS AND DISCUSSION

Validation of the QTI

Table 3 shows that the alpha coefficient calculated in this study for different QTI scales ranged from 0.64 for the Admonishing scale to 0.87 for the Helping/Friendly scale, which are above the recommended 0.60 (Nunnally, 1967), thus illustrating solid reliability.
Table 3
*Internal Consistency (Alpha Reliability) and Ability to Differentiate Between Classrooms for the QTI Scales*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Alpha Reliability</th>
<th>ANOVA results (eta²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Leadership</td>
<td>0.84</td>
<td>0.16***</td>
</tr>
<tr>
<td>CD Helping/Friendly</td>
<td>0.87</td>
<td>0.26***</td>
</tr>
<tr>
<td>CS Understanding</td>
<td>0.82</td>
<td>0.19***</td>
</tr>
<tr>
<td>SC Student Responsibility/Freedom</td>
<td>0.65</td>
<td>0.10***</td>
</tr>
<tr>
<td>SO Uncertain</td>
<td>0.75</td>
<td>0.07***</td>
</tr>
<tr>
<td>OS Dissatisfied</td>
<td>0.79</td>
<td>0.13***</td>
</tr>
<tr>
<td>OD Admonishing</td>
<td>0.64</td>
<td>0.21***</td>
</tr>
<tr>
<td>DO Strict</td>
<td>0.74</td>
<td>0.30***</td>
</tr>
</tbody>
</table>

*** p<0.001 n = 313

Copious amounts of research using a one-way ANOVA have been carried out. It has been concluded that the QTI has the ability to be able to differentiate between the perceptions of students in different classrooms. Students in the same classroom should perceive their environment similarly; however, class perceptions should alter from class to class. This concept was checked for the classes in this study by using a one-way ANOVA, with class membership as the main effect. It was found that each QTI scale differentiated significantly between classes (p<0.001) and the eta² statistic (Table 3), representing the proportion of variance in scale scores (class membership) ranged from 0.07 for the Uncertain scale to 0.30 for the Strict scale, indicating adequate scale differentiation. This analysis indicates that each scale of the QTI is capable of differentiating significantly between classes and it is a valid instrument to measure students’ perceptions of teacher-student interpersonal behaviour.

**Scale means**

The scale means in Table 4 reveal that students perceived that their teachers were strongest in understanding and helping/friendly behaviour, followed closely by displaying good levels of leadership. Students perceived their teachers as exhibiting low levels of uncertain, dissatisfied and admonishing behaviour and seldom allowing student responsibility or being overly strict.

Table 4
*Scale Means and Standard Deviations for QTI Scales*

<table>
<thead>
<tr>
<th>Scale</th>
<th>Scale Means</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC Leadership</td>
<td>2.74</td>
<td>0.74</td>
</tr>
<tr>
<td>CD Helping/Friendly</td>
<td>2.86</td>
<td>0.86</td>
</tr>
<tr>
<td>CS Understanding</td>
<td>2.91</td>
<td>0.76</td>
</tr>
<tr>
<td>SC Student Responsibility/Freedom</td>
<td>1.53</td>
<td>0.60</td>
</tr>
<tr>
<td>SO Uncertain</td>
<td>0.74</td>
<td>0.65</td>
</tr>
<tr>
<td>OS Dissatisfied</td>
<td>0.84</td>
<td>0.72</td>
</tr>
<tr>
<td>OD Admonishing</td>
<td>1.37</td>
<td>0.67</td>
</tr>
<tr>
<td>DO Strict</td>
<td>1.81</td>
<td>0.74</td>
</tr>
</tbody>
</table>

n = 313
Inter Scale correlations

The circumplex nature of the QTI was also checked. Generally, the scale correlations test the circumplex nature of the QTI, that is, the scales should correlate closely with adjacent scales and negatively with those opposite. That is, as one moves around the model, the correlations should become lower. These figures and the scale correlations in Table 5 and the example in Figure 2 confirm the assumptions of the circumplex nature of the Model of Interpersonal Behaviour (Wubbels, Créton, Levy, & Hooymayers, 1993).

Table 5
QTI Inter Scale Correlations

<table>
<thead>
<tr>
<th></th>
<th>CD</th>
<th>CS</th>
<th>SC</th>
<th>SO</th>
<th>OS</th>
<th>OD</th>
<th>DO</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>0.73</td>
<td>0.74</td>
<td>0.11</td>
<td>-0.53</td>
<td>-0.57</td>
<td>-0.41</td>
<td>-0.39</td>
</tr>
<tr>
<td>CD</td>
<td>0.81</td>
<td>0.34</td>
<td>-0.46</td>
<td>-0.60</td>
<td>-0.47</td>
<td>-0.56</td>
<td></td>
</tr>
<tr>
<td>CS</td>
<td>0.34</td>
<td>-0.47</td>
<td>-0.63</td>
<td>-0.57</td>
<td>-0.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SC</td>
<td>0.11</td>
<td>-0.10</td>
<td>-0.13</td>
<td>-0.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO</td>
<td>0.57</td>
<td>0.42</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OS</td>
<td>0.55</td>
<td>0.60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.50</td>
</tr>
</tbody>
</table>

Figure 2. Example of interscale correlations for the Helping/Friendly scale.

These results confirm the circumplex nature of the QTI, further justifying that the QTI can be used with confidence to examine teacher interpersonal behaviour and classroom environment.

VALIDATION OF SMASES

Another main objective of this study was to determine the validity of the motivation scales of the SMASES. It was the intent of this research to use the SMASES to measure students’ levels of motivation in science. These measures were then able to be correlated against the scales of the QTI to identify the type of teacher that students’ perceived enhanced their motivation to learn science.

Internal consistency

The alpha reliabilities for the three motivation scales of the SMASES recorded in Table 6, show 0.80 for Student Learning, 0.75 for Performance Goal and 0.81 for Achievement Goal. These values provide evidence
to suggest that the SMASES is a reliable instrument designed to evaluate students’ perceptions of their motivation in science.

Table 6
Internal Consistency Alpha Reliability for the SMASES

<table>
<thead>
<tr>
<th>Scale</th>
<th>Alpha Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Learning</td>
<td>0.80</td>
</tr>
<tr>
<td>Performance Goal</td>
<td>0.75</td>
</tr>
<tr>
<td>Achievement Goal</td>
<td>0.81</td>
</tr>
</tbody>
</table>

Having provided evidence of the reliability and validity for the QTI and SMASES, associations between the QTI scales and the SMASES scales were then investigated.

ASSOCIATIONS BETWEEN QTI SCALES AND SMASES SCALES

This study investigated associations between the outcomes of student motivation and the eight scales of the QTI. Simple ($r$) and multiple ($R$) correlation analyses were used on the data that were collected from 313 students. In this research, the simple correlations ($r$) describe the bivariate associations between the outcomes and each scale of the QTI. The multiple correlation ($R$) describes the multivariate association between an outcome and a specific scale, when all other scales are controlled.

Achievement goals and teacher-student interpersonal behaviour

The simple correlation data ($r$) in Table 7 indicate that all associations between students’ achievement goals and the QTI scales are statistically significant, except for the Strict scale. That is, teachers’ strict behaviour does not have a significant statistical influence on determining students’ achievement goals. Again the Leadership, Helping/Friendly, Understanding and the Student Responsibility and Freedom scales have a positive influence on students being motivated to achieve in science. Whereas, uncertain, dissatisfied and admonishing behaviours have a negative impact on students’ desire to achieve. When the interrelationships of the QTI scales are controlled and the standard regression weights ($\beta$) are examined, two out of the eight scales produce significant relationships. The Leadership scale remains a significant ($p<0.05$) influence on student achievement goals in science and the Strict scale becomes significant ($p<0.05$). It is noted that the effect of the Strict scale is apparently masked by associations with the other scales in the simple correlation. The multiple correlation ($R$) statistic of 0.39 ($p<0.001$) suggests that there is a strong association between students’ perceptions of teacher-student interpersonal behaviour, as measured by the QTI and students’ achievement goals, thus, motivation in science. The $R^2$ statistic indicates that 15% of the variance in students’ achievement goals is explained by students’ perceptions of teacher-student interpersonal behaviour.

Table 7
Significant Associations between QTI Scales and Achievement Goals in Science in terms of Simple Correlations ($r$) and Standardised Regression Coefficients ($\beta$)

<table>
<thead>
<tr>
<th>Scales</th>
<th>$r$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>0.35**</td>
<td>0.20*</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>0.33**</td>
<td>0.14</td>
</tr>
<tr>
<td>Understanding</td>
<td>0.32**</td>
<td>0.13</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>0.13*</td>
<td>0.07</td>
</tr>
<tr>
<td>Uncertain</td>
<td>-0.18**</td>
<td>-0.01</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>-0.21**</td>
<td>-0.02</td>
</tr>
<tr>
<td>Admonishing</td>
<td>-0.15**</td>
<td>0.01</td>
</tr>
<tr>
<td>Strict</td>
<td>-0.10</td>
<td>0.18*</td>
</tr>
<tr>
<td>Multiple R</td>
<td>$R = 0.39***$</td>
<td>$R^2 = 0.15$</td>
</tr>
</tbody>
</table>

* $p<0.05$ ** $p<0.01$ *** $p<0.001$ n=313
Student learning and teacher-student interpersonal behaviour

The simple correlation ($r$) data in Table 8 indicates that all associations between the value students place on learning and the QTI scales are statistically significant, except for the Student Responsibility and Freedom scale. Moreover, there are significant positive associations with the Leadership, Helping/Friendly and Understanding scales and negative associations with the Uncertain, Dissatisfied, Admonishing and Strict in relation to student learning. Thus, the positive influences on student learning can be attributed to teacher interpersonal behaviour that displays leadership, helping/friendly and understanding traits. The uncertain, dissatisfied and admonishing behaviour of teachers has a significant negative impact or decreases the importance that students place on learning. An examination of the student learning outcomes regression weights ($\beta$) indicate that only one of the seven scales retain their statistical significance. Thus teachers’ leadership behaviours are most influential on students’ motivation to learn science. The multiple correlation ($R$) statistic of 0.53 ($p<0.001$) indicates a significant association between teacher-student interpersonal behaviour and students’ learning value aspect of motivation. The $R^2$ statistic indicates that 28% of the variance in students’ learning can be attributed to their perceptions of teacher interpersonal behaviour.

<table>
<thead>
<tr>
<th>Scales</th>
<th>$r$</th>
<th>$B$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>0.50**</td>
<td>0.36***</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>0.45**</td>
<td>0.15</td>
</tr>
<tr>
<td>Understanding</td>
<td>0.43**</td>
<td>0.04</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>0.09</td>
<td>-0.02</td>
</tr>
<tr>
<td>Uncertain</td>
<td>-0.24**</td>
<td>0.10</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>-0.37**</td>
<td>-0.12</td>
</tr>
<tr>
<td>Admonishing</td>
<td>-0.26**</td>
<td>-0.01</td>
</tr>
<tr>
<td>Strict</td>
<td>-0.25**</td>
<td>0.03</td>
</tr>
<tr>
<td>Multiple R</td>
<td>$R = 0.53$***</td>
<td>$R^2 = 0.28$</td>
</tr>
</tbody>
</table>

Performance goals and teacher-student interpersonal behaviour

In Table 9, the simple correlation ($r$) data identifies four of the eight scales of the QTI as being positively associated with students’ performance goals. With performance goals as the dependent variable, the Leadership, Helping/Friendly, Understanding and Student Responsibility and Freedom scales are statistically significant. Using the more conservative standardised regression coefficient ($\beta$) it is obvious that the Leadership and Student Responsibility and Freedom retained their significance, and the Strict scale became significant, thus having an impact on the level of students’ performance goals. The multiple correlation was 0.38 which was statistically significant and the $R^2$ value of 0.15 illustrated that 15% of the variance in students’ performance goals was indicative of their teachers’ interpersonal behaviour.

<table>
<thead>
<tr>
<th>Scales</th>
<th>$r$</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>0.32**</td>
<td>0.31**</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>0.27**</td>
<td>0.16</td>
</tr>
<tr>
<td>Understanding</td>
<td>0.24**</td>
<td>-0.01</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>0.15**</td>
<td>0.13*</td>
</tr>
<tr>
<td>Uncertain</td>
<td>-0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>-0.11</td>
<td>0.04</td>
</tr>
<tr>
<td>Admonishing</td>
<td>-0.10</td>
<td>-0.02</td>
</tr>
<tr>
<td>Strict</td>
<td>-0.02</td>
<td>0.19**</td>
</tr>
<tr>
<td>Multiple R</td>
<td>$R = 0.38$***</td>
<td>$R^2 = 0.15$</td>
</tr>
</tbody>
</table>

*$p<0.05$ **$p<0.01$ ***$p<0.001$ n=313
CONCLUSIONS

The primary goal of this study was to confirm the validity of the QTI in junior science classrooms. The QTI demonstrated acceptable reliability and validity and substantiated its ability to differentiate between classrooms. The interscale correlations fitted the circumplex model and the scale means illustrated that students perceived their teachers to be good leaders, helping/friendly and understanding. The second goal was to investigate the associations between the QTI and the motivation scales of the SMASES.

This research is effective, in that for the first time it presents the feasibility of using the QTI in conjunction with the SMASES to assess teachers’ impact on students’ motivation towards science. Comparisons of teachers’ interpersonal behaviour and its effectiveness on student motivation as perceived by students, evinced that students are most receptive to teachers who display understanding, helpful/friendly and leadership qualities in the classroom.

This study certainly alerts teachers to the perceptiveness of young adolescents. Such research offers avenues by which teachers can reflect upon ways in which they can modify their interpersonal behaviour in order to increase, re-direct or challenge students’ motivation. It is a distinctive study by the manner in which it identifies viable means for teachers to better manage their classroom environment. It is evident from this research that deterioration in teacher-student relationships in the classroom can repress students’ motivation for science.

The three areas of motivation addressed in the SMASES, Achievement Goals, Student Learning and Performance Goals were influenced by students’ perceptions of teacher interpersonal behaviour. These results were highlighted in Tables 7, 8 and 9 and suggested that students’ achievement goals were positively influenced by teachers’ leadership and strict behaviours. Student learning was significantly influenced by the depth of leadership teachers exhibited in the science classroom. Performance goals by students were influenced by the quality of teacher leadership, the perceived amount of student responsibility and freedom teachers provided for their students and by teachers’ strict behaviours they illustrated when controlling the class.

REFERENCES


ABSTRACT

To develop sound and constructive ESP Tourism courses at Udon Thani Rajabhat University, this study explored English language needs from the professionals in the tourism industry. Data on the communicative needs of the industry were gathered from graduate employees in hotel, travel agency and airline sectors, workplace supervisors, ESP Tourism teachers and university administrators. On the basis of the perceptions of needs obtained from the group of stakeholders and the underlying communicative theoretical model derived from Canale and Swain (1980), Bachman (1990), and Bachman and Palmer (1996), this study proposes five communicative categories that can be used to encourage learners’ communicative ability in ESP Tourism.

INTRODUCTION

According to Chaisawat (2006), the Asia-Pacific region is the world’s fastest growing tourism area in terms of visitor arrivals and Thailand is one of the countries that has experienced tourism growth (p.198). Each year the number of foreign travelers visiting Thailand has increased gradually (Permtanjit, 2003; Sucompa, 1998). Due to the large number of foreign tourists visiting the country, English is widely used in the Thai tourism industry (Chunthawithet, 1997; Foley, 2005) particularly in the interactive communication between tourists and tourism workers (Horey, 1991; Soonthornmaruerangsee, 2006). As a result, competent target language users are required in the tourism market (Sheldon, 1989; Tan & Morgan, 2001). Tourism businesses in Thailand such as travel agencies, airlines, hotels and restaurants require employees who have a high command of English proficiency in order to effectively serve foreign customers (Permtanjit, 2003; Soonthornmaruerangsee, 2006; Sucompa, 1998). Furthermore, the needs for skilled personnel to work in the tourism context is steadily increasing (Soonthornmaruerangsee, 2006).

However, previous tourism studies have shown that the English proficiency of Thai tourism personnel does not seem to reach a satisfactory level. For instance tourism workers do not possess sufficient knowledge and command of foreign languages, especially English (Esichaikul & Baum, 1998; Kongcharoen, 1990; Prasirtsuk, 1993). Workers have problems in speaking and listening whether in face to face communication or telephone conversation (Sucompa, 1998). According to Permtanjit (2003), airline staff confront linguistic barriers regarding pronunciation and unfamiliarity of passengers’ accents. Moreover, the shortage of skilled personnel is one of the major problems of tourism development in Thailand (Esichaikul & Baum, 1998).

Therefore, to promote tourism businesses in the country, it is essential to enhance communicative ability of tourism workers or those who would like to enter the tourism market, so that they can perform effective job in the professional context. Tertiary education and educators have an important role to play in terms of developing and encouraging communicative competence of students. As Soonthornmaruerangsee (2006) suggests “it is necessary that universities and colleges equip their graduates with adequate ability in English together with knowledge of a particular field or career before entering the job market” (p.16). Importantly, language teachers should be aware of real life situations and modify their courses in order to exploit language ability of learners. Then, educational institutions can produce competent graduates to fulfil the demands of the society. As Huang (2004) summarizes “the tourism industry will be successful if they have a well-educated, well-trained, bright and energetic workforce” (p.244).

IMPLICATIONS FOR ESP TOURISM TEACHING AND LEARNING

In order to develop sound and constructive ESP Tourism courses at Udon Thani Rajabhat University, the English language needs of professionals in the tourism industry was investigated. Data on the communicative needs of the industry were gathered from graduate employees in the hotel, travel agency and airline sectors, workplace supervisors, ESP Tourism teachers and university administrators. On the basis of the perceptions of needs obtained from the group of stakeholders and the underlying communicative theoretical model derived from Canale and Swain (1980), Bachman (1990), and Bachman and Palmer (1996), five communicative categories were proposed to be used to encourage learners’ communicative abilities in ESP Tourism. These categories include: enhancing job related communicative functions, mastering language structure, promoting communication strategies, raising cultural awareness and sociolinguistic knowledge and developing on the job knowledge and problem solving skills.
The aim of this paper is to use the proposed communicative framework to suggest how the current ESP Tourism curriculum at the university could be modified to fulfill the needs of various client groups. The recommendations and suggestions for ESP Tourism course development are proposed on a basis of two interrelated and significant questions: what do we teach? and how do we teach? (Breen & Candlin, 1980; Littlewood, 1991) Importantly, these two questions are directly involved in the pedagogical process, and ESP teachers can gain immediate benefit by adapting or translating the proposed recommendations into actual instructional content. This could lead to desirable and successful teaching and learning outcome in the educational context.

ENHANCING JOB RELATED COMMUNICATIVE FUNCTIONS

Obviously, listening and speaking are the most needed skills in the tourism industry (Huang, 2004; Permtanjit, 2003; Sucompa, 1998). This study then further explored whether in a tourism career, what particular functions are most used under listening and speaking modes. Regarding the perceptions of graduate employees in Figure 1.1, speaking functions frequently used by over 50% of the graduates include expressing gratitude, greeting, leave taking, suggesting, describing, offering, persuading and apologizing.

Figure 1. Percentage of daily speaking functions perceived by graduate employees

![Figure 1. Percentage of daily speaking functions perceived by graduate employees](image1)

However, judging from the results of the study, listening functions used on the job are somewhat different. Figure 1.2 shows that apart from socializing functions, listening functions consistently used on a daily and weekly basis include requesting, expressing appreciation, suggesting and complaining. These findings can be used to prioritize language functions taught in ESP course content so that learners can familiarize themselves with language functions that are most relevant to the professional setting.

To ensure that learners are capable to produce the language confidently under the key speaking or listening functions, spiral sequencing approach can be employed in the content knowledge. Richards (2001) points out
that this approach involves the recycling of items to ensure that learners have repeated opportunities to learn them. This can enrich their competence in using the target language.

**USING LANGUAGE STRUCTURE TO ASSIST COMMUNICATION**

According to scholars, grammatical competence is an essential component of communicative competence and deserves a place in language teaching curriculum (Canale & Swain, 1980; Hartoyo, 1998; Richards, 2001; Savignon, 1991; Ur, 1988). Hedge (2000) has argued that it might have been a misconception about communicative language teaching that it does not aim for a high standard of formal correctness (p.47). In teaching language use, Tomlinson (1998) emphasizes that learners need rules and learners need to learn to get things right (p.88).

To prepare non-native learners for spoken interaction with native speakers of English in the tourism workforce, knowledge of grammar should be taught in order to assist them to carry out communicative purposes. In ESP instruction, grammatical issues should be given attention, so that learners can be encouraged to communicate properly and effectively. As Sucompa (1998) points out it is important for tourism students to be proficient in both communication and correct structure (p.118).

As language functions are provided in the subject content, it is worth suggesting that accurate grammatical forms or proper expressions should be introduced to learners via these particular functions. Then, they can make use of linguistic features learned to generate effective interactive communication in their real life. As Willis (2003) puts it “in learning a foreign language, it is important to learn the formulae which govern basic exchanges and the forms of language which realise these exchanges” (p.195). Some examples of linguistic structure that can be adapted to ESP instruction include:

**Function of requesting:**

A: Can/Could/Would you…….please?
B: Certainly/Of course/Sure/I'm sorry…./I'm afraid not……
A: Could I have….please?
B: Certainly/I'm sorry

**Function of offering:**

A: Can/May/Could I……
B: Thanks/thank you very much
A: Would you like me to…..would you like…..
B: Thanks/thank you very much

(2003, p.195)

Apart from teaching formulaic expressions, it is important to inform learners about the formality and informality of language as well as the appropriateness of linguistic form to use. For the function of greeting, people can greet in a variety of ways e.g. How do you do?, Good morning/ Good evening, Hello/Hi, What's up?, How’s it going? (Bowe & Martin, 2007). However, in the tourism context learners should be told that it is too formal to greet tourists with ‘how do you do’ as it is highly valued at a formal occasion (Bowe & Martin, 2007). Besides, learners should be taught that how do you do is only used in face to face encounter (Paulston, 1992).

For the function of suggesting, Canale & Swain (1980) explain that if a waiter tries to encourage a customer to order “I suggest you try the fish” is a more clear cut and obvious grammatical coding than “Have you never tried our fish?, the fish is nice” (p.21). Therefore, in teaching language functions, it is necessary for teachers to encourage learners to become aware of the appropriateness of linguistic formulas use and give them a choice of language to express common functions in the English language (Hedge, 2000).

**Pronunciation** In order to make themselves understood in the tourism industry, learners should realize that it is necessary to produce accurate pronunciation in the spoken language. As Hedge (2000) points out “part of speaking the English language competently is the ability to produce its sounds in ways that are intelligible to other speakers” (p.268). Moreover, Sucompa (1998) and Permntanjit (2003) note that accurate pronunciation should be emphasized for Thai learners in ESP teaching. According to questionnaire data, graduates were confronting pronunciation difficulties at work. Some of their responses include “if you pronounce the word “milk” without “k” sound, native speakers will not understand what you said” (R11), or “I told the customers to go “M” floor but they go the “eight” floor” (R60). Thus, it is worth noting that pronunciation accuracy should be highlighted in verbal communication activities.

In enhancing the quality of students’ pronunciation in ESP Tourism class, teachers should give corrective feedback during oral tasks (Crozet, 1997). Considering the small number of foreign teachers at the institution, teachers can use a sound laboratory to provide pronunciation lessons for learners (Sucompa, 1998). However, the important issue in language teaching is native-like pronunciation should not be the target for non-native learners. As Crozet (1997) states “too much emphasis in a language course on the production of native-like pronunciation
can generate identity distress in learners as well as feelings of failure which can inhibit verbal production” (p.48). Therefore, the aim of encouraging pronunciation of learners in the language class is to get them to pronounce accurately enough to be easily comprehensible to other competent speakers (Ur, 1996).

**ENHANCING COMMUNICATION STRATEGIES**

According to research findings, the speakers’ accents tend to be problematic area for the graduate employees (hotel graduate employees 39.4%, travel agency graduate employees 18.2%, airline graduate employees 36.4%). This is congruent with the study of Permtanjit (2003). The author reported that the unfamiliarity of passengers’ accent is the major problem for the flight attendants. It should be noted that communicative problems occurred in the tourism context because workers have to deal with people from varying countries. It is essential for ESP teachers to be aware of real life situation and introduce appropriate communication strategies in teaching and learning activities. Then, learners can use those strategies to cope with language difficulties encountered in their everyday life.

From the findings of the study, graduates use verbal and non-verbal communication strategies to overcome communication difficulties in the workplace. Verbal communication strategies that the graduates employed consist of grasping context clue or key word, requesting for slower speech, confirming or requesting for repetition. For nonverbal communication strategies, they use writing, drawing or body language. These strategies should be included in communicative exchanges or dialogues so that students learn how to use them appropriately.

Concerning language teaching, communication strategies can be linked to functional activities such as requesting or complaining. In the tourism workforce, workers have to listen to customers’ complaints from time to time (Sucompa, 1998). In the classroom learners should be encouraged to realize that when customers are frustrated, they tend to speak really fast. Communication strategy that they can use is to calm them down and ask them to repeat their needs in a professional way. Instead of saying “Sorry I cannot catch what you said. Can you say it again please?” it might be better for learners to say “Yes, I’m trying to help you Madame/Sir. So can you tell me your problems again please so that I can fix it for you”. In case that the graduates are not in the position to help the customers, they can possibly ask somebody to help and reassure the customers that they will be looked after. This technique can ease the difficult situation to some extent.

When dealing with people from different countries, it seems impossible for non-native learners to comprehend all of the accents from around the world. In the teaching environment, ESP teachers could familiarise learners with the accents of the tourists who are constantly visiting Thailand for instance British, American, European, Australian and Asian. However, the speakers’ accents provided in teaching materials should be realistic and natural so that learners are aware of the speed of the tourists speech and learn to use communication strategies when needed.

**ENCOURAGING CULTURAL UNDERSTANDING AND SOCIOLINGUISTIC KNOWLEDGE**

To prepare learners for the tourism market, (apart from enhancing linguistic aspects of communication) cultural understanding is another issue that should be introduced in language teaching. According to Gudykunst and Kim (1997) “in a world of international interdependence, the ability to understand and communicative effectively with people from other cultures takes on extreme urgency” (p.4). Moreover, Prodromou (1992) points out that “in teaching English we can impart to learners not only the present perfect but also the power of knowing and caring more about the world they live in” (p.47). Previous studies in Thai and Chinese tourism contexts similarly indicated that knowledge of cultural differences should be included in language courses (Huang, 2004; Permtanjit, 2003; Sucompa, 1998).

Therefore, to better prepare learners for the culturally diverse workforce, it is essential to impart some knowledge of cultural understanding in the early stages of their study. This can help them become more aware, and become more culturally sensitive, when conversing with native/non-native tourists in their future career. From the viewpoint of Sucompa (1998), to provide a good service and please the customers, tourism workers need to learn crosscultural differences (p.96). Moreover, Dudley-Evans, and St. John (1998) point out that “a sensitivity to cultural issues and an understanding of our own and others’ values and behaviours is important in ESP” (p.66).

In ESP teaching and learning, cultural understanding can be demonstrated through the use of language functions e.g. greeting, leave taking, thanking or expressing appreciation. The benefit is that apart from learning language use, learners can be encouraged to realize and notice the differences between native culture and target culture.

Furthermore, sociolinguistic competence or the use of the appropriate linguistic codes in a context (Tseng, 2002) should be developed for learners. Then, learners can use this knowledge to assist them to communicate appropriately with native and non-native speakers. According to Canale and Swain (1980), the appropriateness of the utterances produced will depend on contextual factors such as topic, role of participants, settings and norms of interaction. Therefore, ESP teachers should enhance learners to be aware of these contextual factors
when illustrating communicative language activities. Homes and Brown in Wolfson (1989) address that it is the teacher’s responsibility to provide feedback to students concerning the appropriate or inappropriate use of English, since the students themselves are likely to be unaware of many of their errors in this area (p.32). If learners are encouraged to develop sociolinguistic competence, it can help them use the target language effectively and appropriately in their real life.

**PROVIDING ON THE JOB KNOWLEDGE AND PROBLEM SOLVING SKILLS**

**Knowledge of tourist attractions**

According to the perceptions of graduate employees and workplace supervisors, knowledge of tourist attractions is necessary for tourism workers. In their routine job, tourists tend to ask something like What should I visit in this area?, How can we go to that place?, Where can I eat out?” or Where can I buy ….? etc. Moreover, previous studies suggested that knowledge of tourism attractions should be included in the course content (Kongcharoen, 1990; Sucompa, 1998). Therefore, learners should be given adequate knowledge of this particular issue so that they can adequately address the enquiries of the tourists.

As there are many remarkable tourist attractions in Thailand, Tejavanija (2002) recommends that major tourist attractions required by Tourism Authority of Thailand for official tour guide license can be taught. In the early stage of ESP teaching it might be better for learners to have an overview of famous places in Thailand. Then, they can practice giving information about tourist attractions in the country (Kongcharoen, 1990). Once learners are confident in their ability to provide general details to the tourists, then, in the next stage, they can be trained to deliver specific information on particular places, which can be obtained from available provincial websites such as www.udonthani.com, www.khonkaen.com, and www.bangkok.com.

**Problem solving skills**

From the findings, graduate employees and workplace supervisors expressed similar concerns that skill of problem solving is needed for tourism career. From the opinion of tourism management, university students should have the ability to handle problem solving as there are problems to solve everyday in the world of work. Previous studies have shown that skills of problem solving are required for those who would like to enter the industry of tourism (Chaisawat, 2006; Tan & Morgan, 2001; Tejavanija, 2002). The findings from relevant studies is adequate to confirm that it is crucial to develop problem solving skills for learners in the process of teaching and learning. In the first year of study, it might be best to raise learners’ awareness about problems they are going to confront in the tourism workforce. The perspectives of workplace supervisors regarding real life problems can be useful for teachers. For instance, the usual problem in airline sectors is that passengers come to check in late because they did not read the regulations carefully. In hotel settings, one hotel manager said clients can be very demanding when booking through travel agency. Some prefer smoking floor or some request double bed. Once they arrive and do not get what they expect, there will be problems. Therefore, hotel staff should be capable to fulfill the clients’ needs. To provide relevant and authentic ESP Tourism course it is worth suggesting that work related problem solving activities should be incorporated for the benefit of learners. This can be best illustrated through the function of complaining. Thus, learners can be well prepared in how to use language to cope with unexpected or unpleasant situations in the occupational context.

It should be noted that the implications and recommendations in this paper are deliberately presented more in the form of general principles or guidelines than detailed prescriptions. Considering that in any institution, teachers may vary according to language proficiency, teaching experience, teaching style or skill and expertise (Richards, 2001). Therefore, it is considered practical to give teachers more freedom and flexibility in terms of how they interpret these communicative categories and apply them to their actual teaching practice. The researcher believes that, with this guideline, learners’ communicative skills can be enhanced. They can then use the target language confidently and effectively in the cross-cultural world.

**REFERENCES**


ABSTRACT

Science and technology are considered to be the key for sustainable economic development in the future. As such, schools are expected to provide science education that is relevant to meet this challenge. This would entail teachers to reevaluate their teaching approaches in particularly in ensuring students to gain equal access to science and making science learning a meaningful experience. In order this can take place, teachers must provide a learning environment where students experience comfort and security in science classes. This requires teachers to demonstrate ‘good leadership’ and ‘cooperative’ behaviours in science classes. The purpose of the present study was to investigate science students’ perceptions of teachers’ interpersonal behaviour in lower secondary science classes.

The study involved 1149 grades 7, 8, and 9 students in secondary public schools in Brunei Darussalam, of which 541 were males and 608 were females. The study found that teachers were showing good leadership and cooperative behaviour in science classes. Furthermore, the study found that students’ gender and grade levels had little effect on their perceptions of teachers’ interpersonal behaviour. The paper was concluded with discussion on its implications in the teaching of science.

INTRODUCTION

The impact of science and technology on society has changed the direction of science education in many developing countries. This is so because science and technology are perceived to be the key for sustainable economic and social development in many developing countries including Brunei Darussalam. To meet this challenge there has been a call for every citizen to be scientifically literate. A consensus view is that every man should appreciate that science is a cultural activity, well aware of that science helps people to make sense of and understand the world around them, and recognize that practice of science is transferable to work places and helps people be more skillful in decision making and at the same time preparing for future scientists. To keep abreast with the changes in science and technology, schools are expected to provide science education that is relevant and meaningful to daily and later lives of the students. This would entail teachers to reevaluate their teaching approaches, particularly in ensuring students to gain equal access to science and making science learning a meaningful experience. Wubbels, Creton and Hooymayers (1985, 1992) noted that there are two important aspects of teacher behaviour which are central for teaching and learning. These two aspects are teaching methodology and teacher-student relationships. They argued that these two aspects are interconnected in which a failure on the part of teachers to develop positive relationship with students may cause teaching and learning would not take place. Therefore it is important to study teacher-student relationships. Consequently, this study investigated lower secondary science students’ perceptions of teachers’ interpersonal behaviour in secondary schools classes in Brunei Darussalam.

Interpersonal teacher behaviour

The theoretical framework that underpins interpersonal teacher behaviour was developed by Wubbels, Creton, Levy and Hooymayers (1993). They argued that teacher interpersonal behaviour is a result of teacher–student interactions in a classroom where teacher behaviour is influenced by student behaviour and which in turn influences student behaviour. Consequently circular process is developed in the teacher-student interactions. They also developed a graphical model to represent different facets of teacher-student interactions (Fig. 1). By using the model, it is possible to present teacher or student behaviour at any instant. According to the model, any teacher interpersonal interaction with students lies between two axes namely; a proximity dimension (Cooperation, C – Opposition, O) which describes degree of cooperation or closeness between people involve in communication and an influence (Dominance, D - Submission, S) dimension which describes who is directing or controlling the communication. Using this model, they identified eight different types of interpersonal behaviours. These are Leadership,
Helping/Friendly, Understanding, Student Responsibility and Freedom, Uncertain, Dissatisfied, Admonishing and Strict behaviours. These behaviours are represented by eight equal sectors and shared between the two dimensions according to their position in the co-ordinate system of the model as shown in Figure 1. Based on this model Wubbels, et al. (1985) developed a questionnaire called the Questionnaire on Teacher Interaction (QTI) for describing and assessing teacher’s behaviour in classrooms.

Since its development a number of studies on teacher interpersonal behaviours were conducted in Asia. (Goh & Fraser, 1998; Fraser & Aldridge, 2001; Khine and Fisher, 2004; Kim, Fisher, & Fraser, 2000; Kijkosol & Fisher, 2004; Koul & Fisher, 2003; Riah, 2000; Riah & Fraser, 1998; Scott & Fisher, 2001, 2002; Yong, 2005a, 2005b). Many of these of these studies investigated students’ perceptions of the actual teacher interpersonal behaviour in classrooms. For example Kim, et. al. (2000) found that the 543 Grade 8 students from 12 Korean secondary schools described their biology teachers as good leaders, helpful and friendly and understanding. The Korean teachers were seldom uncertain, dissatisfied, admonishing and strict. Similar results were reported by Koul and Fisher (2003) when they investigated secondary school teachers’ interpersonal behaviour in India. They found that Indian students perceived their teachers demonstrated leadership, helping/friendly, understanding and giving students responsibility and freedom behaviours. Furthermore, they noted that the students noticed less of the negative behaviours of the teachers such as uncertainty, dissatisfaction, admonishing and strict behaviours. Similarly Kijkosol and Fisher (2004) reported that Grade 10 biology students in Thailand perceived their biology teachers were exhibiting higher level of positive behaviours in terms of Leadership (DC), Helping/Friendly (CD) and Understanding (CS) behaviours. These studies indicate that generally students perceived their teachers were demonstrating good leadership and cooperative behaviours.

The QTI were also used in investigations of associations between interpersonal behaviour and students’ learning outcomes. These studies indicate that Leadership, Helping/Friendly and Understanding behaviours were positively associated with student attitudes and student achievement, while Uncertain, Dissatisfied and Admonishing behaviours are negatively associated with student outcomes (Fisher, Goh, Wong & Rickards, 1996; Fisher, Henderson & Fraser, 1995; Rickards, Fisher & Fraser, 1996; Riah & Fraser, 1998; Wubbels, Brekelmans & Hermans, 1987; Wubbels, Brekelmans & Hoymayers, 1991; Henderson, Fisher, & Fraser, 2000; Koul & Fisher, 2004; Yong (2005). It can be concluded that teachers who exhibit dominant behaviours (i.e. Strict, Leadership, Helping/Friendly and Understanding behaviours) tend to foster cognitive outcomes, while teachers who show cooperative behaviours (i.e. Leadership, Helping/Friendly and Understanding and Student Responsibility/freedom behaviours) foster students’ affective outcomes.

There were also studies which investigated factors affecting students’ perceptions of interpersonal teacher behaviour. Investigations on the effects of students’ gender on their perceptions of interpersonal teacher behaviour using the QTI generally showed that female students perceived their teachers’ interpersonal behaviour more positively than male students. In particular, female students tended to perceive the interpersonal behaviour of their
teachers more dominant and cooperative than did the male students (Goh & Fraser, 1995, 1998; Levy, Creton & Wubbels, 1993, 2003; Fisher & Rickards, 1998b; Wubbels & Levy, 1993). Fisher and Rickards (1997) reported a study on interpersonal teacher behaviour involving 3515 science students from 173 secondary science classes and 173 teachers and found that females perceived their teachers showing higher levels of Leadership, Helping/Friendly and Understanding behaviours did males, while males perceived their teachers were exhibiting more Uncertain, Dissatisfied, Admonishing and Strict behaviours than did females. In terms of grade levels, there were only a few known studies which explored the effects of students’ grade levels on their perceptions of teachers’ interpersonal behaviour. Levy and his colleagues (Levy, et al., 2003) found that grade levels were only related to the proximity (C-O) dimension; teachers teaching in higher grades were perceived by their students as being more cooperative than did students in the lower grades. Students in the higher grades perceived their teachers were more helpful and friendly and less uncertain than did student in lower grades. These studies suggest that students’ gender and grade levels may affect students’ perceptions of teachers’ interpersonal behaviour.

**Purpose of the study**

The main purpose of the study was to investigate students’ perceptions of teachers’ interpersonal behaviour in science classes in lower secondary schools in Brunei Darussalam. Specifically the study focused on two important research questions:

1. How do lower secondary science students' perceived their teachers’ interpersonal behaviour in secondary schools in Brunei Darussalam?
2. Do students gender and class level affect their perceptions of teachers' interpersonal behaviour?

**METHODOLOGY**

**Sample**

The sample for the study was made up of 388, 382 and 379 grades 7, 8 and 9 students taking science respectively from 48 classes in secondary government schools in Brunei Darussalam. Thus altogether 1149 students involved in the study of which 541 were males and 608 were females. The age of students ranged from 12 to 14 years old. The average class size was 24, and the number of students in each class ranged from 12 to 38.

**Instruments**

Students’ perceptions of interpersonal teacher behaviour were measured by adapting the Singaporean version of the Questionnaire on Teacher Interaction (QTI) (Goh & Fraser, 1998). The QTI has eight scales which represent eight facets of interpersonal teacher behaviour. Each scale has six items. Table 1 gives a description of eight scales and an example of an item for each scale of the instrument. The instrument employed a three-point response format; seldom, sometimes and most of the time. The responses were scored accordingly with seldom as 1, sometimes as 2 and most of the time as 3 respectively.

The instrument was tested for its reliability and validity for use in the present study. The reliability of the QTI used in this study was determined by its internal consistency (Cronbach alpha reliability). The students’ responses on the 48 items of the QTI were subjected to item analysis using the individual student mean as the unit of analysis. It was found that the internal consistency of the different QTI scales ranged from 0.53 to 0.74.
Table 1

<table>
<thead>
<tr>
<th>Scale Description and Example of an Item for Each Scale of the QTI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership (DC)</strong></td>
</tr>
<tr>
<td><strong>Helping/Friendly (CD)</strong></td>
</tr>
<tr>
<td><strong>Understanding (CS)</strong></td>
</tr>
<tr>
<td><strong>Student Responsibility/Freedom (SC)</strong></td>
</tr>
<tr>
<td><strong>Uncertain (SO)</strong></td>
</tr>
<tr>
<td><strong>Dissatisfied (OS)</strong></td>
</tr>
<tr>
<td><strong>Admonishing (OD)</strong></td>
</tr>
<tr>
<td><strong>Strict (DO)</strong></td>
</tr>
</tbody>
</table>

The criterion used for establishing validity of the QTI was its ability to differentiate between the perceptions of students in different classrooms. It is assumed that students within class would perceive a similar environment, while students in other classes would perceive a different environment. This characteristic was determined by a series of one-way analyses of variance for each scale of the QTI. The $\eta^2$ statistic (which is the ratio of ‘between’ to ‘total’ sums of squares and represents the proportion of variance in scale scores accounted for class by membership) ranged from 0.17 to 0.36. The result of the analysis suggests that each scale of the QTI was able to differentiate significantly ($p<0.001$) between students perceptions in different classes.

The results of the statistical tests suggest that the QTI was a valid and reliable instrument for measuring interpersonal teacher behaviour for the present study and provide further cross-validation information about its suitability for use in different cultural context.

**RESULTS AND DISCUSSION**

**Students’ perceptions of interpersonal teacher behaviour**

In order to determine students’ perceptions of their science teachers’ interpersonal behaviour, their responses on the 48 items of the QTI were analysed using descriptive statistics. Table 2 shows students’ perceptions of their science teachers’ interpersonal behaviour using the student’s mean score as the unit of analysis. The mean scores on the scales of Leadership, Helping/Friendly and Understanding behaviours were high while on Uncertain, Dissatisfied and Admonishing scales were low. These results suggest that students perceived that their science teachers were showing high levels of Leadership, Helping/Friendly and Understanding behaviours, and lower level of Uncertain, Dissatisfied and Admonishing behaviours. It is interesting to note that teachers were slightly less strict with and generally giving less responsibility and freedom to their students. Figure 2 shows a graphical representation or profile of students’ perceptions of their teachers’ behaviours. The profile suggests that teachers were good at positive interpersonal behaviour such as noticing what is happening, organising and setting tasks, holding attention when explaining, helpful and friendly to students, and caring, concern and understanding towards students in science classes.
Table 2
Mean and Standard Deviation for Questionnaire on Teacher Interaction (QTI)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Scale mean</th>
<th>Std Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>14.98</td>
<td>2.14</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>14.70</td>
<td>2.44</td>
</tr>
<tr>
<td>Understanding</td>
<td>14.03</td>
<td>2.25</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>10.89</td>
<td>2.26</td>
</tr>
<tr>
<td>Uncertain</td>
<td>8.23</td>
<td>1.62</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>8.44</td>
<td>2.09</td>
</tr>
<tr>
<td>Admonishing</td>
<td>8.17</td>
<td>2.13</td>
</tr>
<tr>
<td>Strict</td>
<td>11.50</td>
<td>2.41</td>
</tr>
</tbody>
</table>

(Range 6 to 18)

According to Levy, Creton and Wubbels (1993), this pattern of teacher behaviour is desirable because, from social expectations, the teacher has always been considered as an expert while students are considered as novices. They believed that it is important for teachers to act both dominantly and cooperatively in order to maintain conducive classroom environments for teaching and learning. These findings replicated previous studies (Riah & Fraser, 1998; Riah, Fraser & Rickards, 1997; Koul & Fisher, 2003; Lee & Fraser, 2001; Scott & Fisher, 2001; Yong, 2005a). Therefore, it can be assumed that teachers demonstrated positive interpersonal teacher behaviour in lower secondary science classrooms in Brunei Darussalam.

Gender differences in students’ perceptions of interpersonal teacher behaviour

This study involved 541 male and 608 females from 48 lower secondary classes in government coeducational schools. Students’ perceptions of interpersonal teacher behaviour were analysed and within-class gender subgroup mean was used as the unit of analysis. The gender differences were explored by paired-samples t-tests and results were presented in Table 3. Comparing the within-class means, it can be seen that five out of the eight QTI scales show significant gender differences ($p<0.01$). These differences were illustrated in Figure 3. However, to assess if these differences were large enough to be educational important, effect sizes for each scale of the QTI that showed differences, were calculated. Table 3 showed that the effect sizes were small ($<0.25$). These results suggested that the differences between males and females perceptions of their lower secondary science teachers were negligible and may not educationally important. The findings of the study appeared to be contrary to the findings as reported in the
previous studies (Goh & Fraser, 1998; Riah, 1998; Riah, et al., 1997; Fisher & Rickards, 1998; Wubbels & Levy, 1993, Yong, 2005b).

Table 3

<table>
<thead>
<tr>
<th>Scale</th>
<th>Male</th>
<th>Female</th>
<th>t-value</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>15.09 0.91</td>
<td>14.87 1.16</td>
<td>3.62*</td>
<td>0.11</td>
</tr>
<tr>
<td>Helping/Friendly</td>
<td>14.55 1.29</td>
<td>14.81 1.66</td>
<td>-3.76*</td>
<td>0.09</td>
</tr>
<tr>
<td>Understanding</td>
<td>14.03 0.94</td>
<td>13.98 1.21</td>
<td>0.80</td>
<td>-</td>
</tr>
<tr>
<td>Student Responsibility/Freedom</td>
<td>10.73 1.04</td>
<td>10.87 1.37</td>
<td>-1.93</td>
<td>-</td>
</tr>
<tr>
<td>Uncertain</td>
<td>8.41 0.93</td>
<td>8.13 0.67</td>
<td>5.88*</td>
<td>0.18</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>8.75 1.10</td>
<td>8.25 1.10</td>
<td>7.32*</td>
<td>0.23</td>
</tr>
<tr>
<td>Admonishing</td>
<td>8.44 1.49</td>
<td>8.01 1.10</td>
<td>5.71*</td>
<td>0.17</td>
</tr>
<tr>
<td>Strict</td>
<td>11.61 1.26</td>
<td>11.52 1.36</td>
<td>1.20</td>
<td>-</td>
</tr>
</tbody>
</table>

*p < 0.01

Figure 3. Profile of female and male students’ perceptions of teachers’ interpersonal behaviour.

Students’ perceptions of teachers’ interpersonal behaviour across grade levels in lower secondary science classes

In order to investigate whether there were differences across grade levels in the students’ perceptions of their teachers’ interpersonal behaviour in lower secondary science classes, one way-ANOVA were conducted for all the scales of QTI. The results of these analyses were presented in Table 4. The F-values in the last column in Table 4 show that seven of the QTI scales were statistically significant. The results suggest that students across grade levels differ in their perceptions of their teachers’ interpersonal behaviour.
Table 4
Mean, Mean Differences and Effect Size (ES) across Grade Levels in Students’ Perceptions of Teachers’ Interpersonal Behaviour

<table>
<thead>
<tr>
<th>QTI Scale</th>
<th>Scale Mean</th>
<th>F-value</th>
<th>Scale Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 7</td>
<td>Grade 8</td>
<td>Grade 9</td>
</tr>
<tr>
<td>Leadership (DC)</td>
<td>15.26</td>
<td>14.83</td>
<td>14.98</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helping/Friendly (CD)</td>
<td>14.74</td>
<td>14.84</td>
<td>14.54</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understand (CS)</td>
<td>14.01</td>
<td>14.25</td>
<td>13.84</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Responsibility/Freedom (SC)</td>
<td>10.59</td>
<td>11.26</td>
<td>10.80</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain (SO)</td>
<td>8.35</td>
<td>8.47</td>
<td>7.89</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissatisfied (OS)</td>
<td>8.68</td>
<td>8.17</td>
<td>8.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admonishing (OD)</td>
<td>8.28</td>
<td>7.94</td>
<td>8.30</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strict (DO)</td>
<td>12.14</td>
<td>10.85</td>
<td>11.51</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.05    **p < 0.01    ***p < 0.001

In order to find out which across grades caused the differences in the means of students’ perceptions of interpersonal teacher behaviours, Scheffe post hoc tests were conducted on the seven QTI scales. The results of the tests were presented in the last three columns of Table 4. Scheffe post hoc tests indicated that Grade 7 and Grade 8 students differed in their perceptions on four of the eight QTI scales. These scales were Leadership, Student Responsibility/Freedom, Dissatisfied and Strict. This suggested that Grade 7 students perceived that their lower secondary science teachers were showing better leadership behaviour, and more strict and dissatisfied behaviours than did Grade 8 students. However, Grade 8 students perceived their teachers had given them more responsibility and freedom than did Grade 7. The Scheffe post hoc tests also revealed that three of the eight scales of QTI showed significant differences between Grade 7 and Grade 9. These scales were Leadership, Uncertain and Strict. In each of these scales, Grade 7 students had higher mean scores than Grade 9 students. Similarly, there were also significant differences in the perceptions between Grade 8 and Grade 9 students. It was found that Grade 8 students had higher mean scores on teachers’ Understanding, Student Responsibility/Freedom, Uncertain and Strict behaviours than did Grade 9 students. It appears that the there was score mean difference for Strict behaviour across the grades with Grade 7 had highest score mean than the grades 8 and 9. Because there were significant score mean differences on seven scales of the QTI across grade levels effect sizes were calculated. It was found that the effect sizes for these score mean differences across the grades in the six scales of QTI were small except the Strict behaviour with a moderate effect size of 0.55 between Grade 7 and Grade 8. These findings suggest there were little differences across the grades in the students’ perceptions of teacher interpersonal behaviour. However, since the Strict behaviour showed significant difference across the grades, it could imply that teachers who were teaching higher grades may experience less discipline problems than did teacher in lower grades. This opinion was supported in which teachers seemed to be giving less Student Responsibility and Freedom to the lower grades than higher grades.
DISCUSSION AND CONCLUSION

The study investigated actual teachers’ interpersonal behaviour towards their students in lower secondary science classes. The results of the study highlighted some important issues in the teaching of science in lower secondary schools pertaining to teacher-student relationships. This study found that teachers’ interpersonal behaviour in lower secondary science classes were favourable. However research indicated that actual interpersonal teacher behaviour often still fell short of ideal ones particularly in terms of Leadership, Helping/Friendly, Understanding and giving Student Responsibility (Brekelmans, Wubbels & den Brok, 2002; Levy, Creton, & Wubbels, 1993). This suggests that there are rooms for teachers need to improve their behaviours towards students particularly those behaviours related to productive learning environment. Brekelmans, Wubbels and Levy (1993) noted that teachers who exhibit Strict, Leadership, Helping/Friendly, Understanding and giving Student Responsibility behaviours would promote learning in science classes. Earlier research indicated that these behaviours are associated cognitive and affective outcomes. Therefore, it is important for teachers to ensure the presence of these behaviours in order to create positive learning environment and improve student learning outcomes.

Another finding of the study was that there were negligible gender differences found in the students’ perceptions of their teachers’ interpersonal behaviour. However teachers still should take note of their interpersonal behaviours towards male and female students to ensure gender equity interactions take place in science classes. On the other hand, differences found in the students’ perceptions of teachers’ interpersonal behaviour across grade levels inform teachers about their relationships with students at different grades. In particular Grade 9 students perceived that their teachers were giving them more responsibility and freedom than Grade 7 students did. The finding implied that students in the higher grades appeared to have less discipline problems explains why teachers more likely to give more responsibility and freedom to higher grade levels students than do students in the lower levels. This suggests that students in lower grades should be given more guidance, help and encouragement in order to take responsibility of their own learning. Hence, teachers who are teaching across grades should take care of their interpersonal behaviours to different age groups of students as well as students across different grade levels.

The study had shown that how teachers interact with their students can be easily interpreted by the students and these were reflected in the students’ perceptions of their teachers’ interpersonal behaviours. Such a reflection is very useful and a valuable information about teacher-student in science classes for teachers and school administrators. Despite teachers were demonstrating ‘good leadership’ and ‘cooperative’ behaviours in this study, yet it highlighted the need for teachers not only to maintain but also to change and improve their interactions with students in science classes. Wubbels (1993) argued that positive teachers’ interpersonal behaviour towards students could contribute to productive learning environment. Thus it is essential for science teachers to inculcate the positive aspects of interpersonal behaviours. This is possible by continuous monitoring of students views of their teachers’ interpersonal behaviours. Fraser (1993) suggested a five-step procedure as basis for improving classroom learning environment. This includes reflection upon, and discussions on student feedback of their interpersonal behaviour, and systematic attempts to improve on those desirable behaviours. Hence at individual level a teacher wishes to monitor or improve his or her interpersonal behaviour towards students could follow these steps.

On the other hand, this information could be useful as bases for decision making by school administrators to send teachers particularly new teachers to attend educational programs and workshops on classroom practices. By attending these programs and workshops teachers may change their attitudes and cognition about classroom practices and develop their interpersonal skills (Wubbels, Creton, & Hermans, 1993).

REFERENCES


LEARNING ENVIRONMENTS ON “ONE DISTRICT : ONE DREAM SCHOOL” PROJECT IN SCIENCE CLASSES IN THAILAND

Toansakul Santiboon
Udon Thani Rajabhat University

Abstract

The Thailand Government launched the ‘One District One Dream School’ project on 1 October 2003, aimed at developing the quality of schools in all districts to ensure that every district has at least one high-quality school. The project was also intended to fulfill children’s dream of attending good schools in their locality. This study investigates students' perceptions of their science classroom learning environments and their interactions with their teachers in “One district, One dream school” project in secondary school classes in Thailand. Associations between these perceptions and students' attitudes toward science were also determined. The learning environment perceptions were obtained using the 35-item Science Laboratory Environment Inventory (SLEI) (Fraser, McRobbie, & Giddings, 1993). The questionnaire has an Actual Form and Preferred Form. Students' attitudes were assessed with the Test Of Science-Related Attitude (TOSRA) (Fraser, 1981). The questionnaires were translated into the Thai language and administered to a sample of 2,280 students in 76 secondary school involved in the project in each district from 76 provinces throughout the Thailand. Statistically significant differences were found between the students' perceptions of actual and preferred environments which shows, significant correlations (p<0.01) between students' attitudinal outcomes and science classroom environment on all scales of the SLEI. Associations between students' perceptions of their learning environments with their attitudes to their science classes were also found. 43% of the variance in student’s attitude to their science class was attributable to their perceptions of their science classroom environments. Based on the finding, suggestions for improving the science classroom environment with students' perceptions are provided.

Introduction

The Government is accelerating its investment in human resource development. Prime Minister Thaksin Shinawatra, in his weekly radio address on 23 July 2005, said that he had called a meeting of education administrators and Cabinet members responsible for education to expedite the Government’s projects to develop human resources. The first project, the “Income Contingency Loan” program, involves a financial reform for university education in connection with future repayment. The second project calls for the installation of computers and Internet access in all schools nationwide within the next two years. The Government plans to install 250,000 computers during the period.

Regarding the third project, “One District, One Dream School,” the Prime Minister said that the Ministry of Education wanted to expand this project to become “One District, Two Dream Schools.” Two dream schools in this context comprise one primary school and one secondary school for use as models for other schools in the same district. Universities and the private and civic sectors would be encouraged to take part in creating the model schools. The principle of the expansion project has received the green light. The three projects on investment in human resource development would be accelerated for further development.

International research efforts over the last 40 years have firmly established classroom environment as a thriving field of study (Fraser, 1994). Recent classroom environment research has focused on science laboratory classroom environments (McRobbie & Fraser, 1993). This study was to describe the determinants and effects of the actual and preferred of students' perceptions to extend this notion in order to obtain more comprehensive picture of science laboratories learning environments within science school classes. Particularly in lower secondary schools, by focusing on students' perceptions of their actual and preferred classroom laboratory environments in science classrooms in Thailand, investigated associations between students' perceptions of their learning environments with their attitudes to their science classes.

Background

Results of the implementation of the Government’s “One District, One Dream School” project in various
parts of Thailand have been satisfactory. The Cabinet, during its meeting on 7 June 2005, acknowledged
the Ministry of Education’s report on progress of the implementation of the project. The Government
launched the One District, One Dream School project on 1 October 2003, aimed at developing the quality
of schools in all districts to ensure that every district has at least one high-quality school. The project was
also intended to fulfill children’s dream of attending good schools in their locality. At the initial stage, one
model school was established in each district, and it would encourage other schools to improve themselves.
The Government wants high-quality schools to be developed in the entire education system to achieve
education reform.

According to the report submitted to the Cabinet, the Government has approved a budget of 2,558 million
baht from the 2004 to 2006 fiscal years to carry out the project. Out of this amount, 1,763 million baht was
allocated for the 2004 fiscal year, 344 million baht for 2005, and 450 million baht for 2006. Prime Minister
Thaksin Shinawatra has urged the business sector and various government agencies to provide support for
these model schools. Tax reductions are offered to those who gave donations to the schools.

The report indicates that the project has received good cooperation from companies, state enterprises, and
local communities, which donated more than 500 million baht worth of equipment. The assistance also
came in the form of advice and activities to help improve district schools. Each school under the project
received 2.5 million baht on average from the Government and another 2.5 million baht from donors. The
money was used mainly to develop libraries and laboratories. Part of the amount was spent on the purchase
of computers for teaching and learning.

Since the beginning of the project in the 2004 fiscal year, people have been satisfied with the project and
are willing to render support. They are confident that schools under the project are of good quality and want
to send their children to attend these schools. As a result, all model schools need to expand their classes, so
that they can accommodate more students. Sometimes the expansion is not possible, as these schools focus
on quality and want all students to gain the maximum benefits from education.

Students in these schools are taught how to think analytically and to seek knowledge from reading.
Moreover, they will be equipped with knowledge on the application of information technology. About 598
schools (www.labschools.net, 2006) under the project have been found to become full dream schools,
where teachers have developed their teaching techniques very well. The model schools have also offered
technical assistance to more than 10,000 smaller schools in adjacent areas. The Ministry of Education
expects that all schools will have their quality improved within the next four years during the term of this
administration. Another 100 billion baht will be required to expand dream schools throughout the country.

Use of learning environment instrument

In the last decade, many countries have used learning environment instruments in conducting research
studies. Some examples of these are the Science Laboratory Environment Inventory (SLEI) was developed
by involving Australian secondary school students (Fraser, 1991) and was extensively validated in diverse
setting such as, the USA, Australia, Canada, England, Israel, Nigeria, Brunei, Singapore, South Korea and
the counties in South Pacific Islands (Fraser, Giddings & McRobbie, 1995; Henderson, Fisher, & Fraser,
2000; Hoffstein, Cohen, & Lazarowitz, 1996; Lee & Fraser, 2001; Wong & Fraser, 1996). Therefore, it was
considered appropriate and helpful to select convenient questionnaires that could be used to investigate the
nature of science classroom and environments.

In addition to a form, which measures perceptions of actual environment, the instruments have an
additional form, which measures preferred environment. The preferred form is concerned with goals and
value orientations as it measures perceptions of the environment ideally liked or preferred. Although item
wording is almost identical for actual and preferred form, the directions for answering the two forms
instruct student clearly as to weather they are rating what their class is actually like or what they would
preferred it to be like.
The Science Laboratory Environment Inventory (SLEI)

Fraser, Giddings, and McRobbie (1993) developed a new instrument specifically suited to assessing the environment of science laboratory classes, the Science Laboratory Environment Inventory (SLEI), has five scales and the response alternatives for each item are Almost Never, Seldom, Sometimes, Often, and Very Often. Since Fraser, Giddings and McRobbie (1993) developed the SLEI by involving Australian secondary school students (Fraser, 1991) and was extensively validated in diverse setting such as, the USA, Australia, Canada, England, Israel, Nigeria, Brunei, Singapore, South Korea, Thailand, and the counties in South Pacific Islands (Fraser, Giddings & McRobbie, 1995; Wong & Fraser, 1996, Lee & Fraser, 2001; Quek, Fraser, & Wong, 2001;). As a result, a Personal Form of the SLEI was developed and later applied to the other instruments in learning environment research (Lee & Fraser, 2001). Santiboon & Fisher (2005), using the SLEI (modified from the original SLEI) investigated to physics laboratory learning environments in upper secondary school in Thailand.

In this present study gives a scale description the actual of each SLEI scales, some items were reworded. Further, because this study was concerned with classroom environment in science laboratory classes. The Thai version was translated the containing the 35-item of the SLEI five scales, namely, Student Cohesiveness (SC), Open-Endedness (OE), Integration (IN), Rule Charity (RC), and Material Environment (ME).

Research Objectives

1. To investigate the students’ perceptions of their actual and preferred classroom environments for assessing and improving in science classes in “One District One Dream School” project in Thailand.
2. To associate between students’ perceptions of their science classroom environments and their attitudes toward science in “One District One Dream School” project in Thailand.

Design and Procedure

The main questionnaires used in this study are SLEI, and the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981a). The attitude questionnaire was selected to use with the aim of investigating any possible relationships with students' perceptions about their laboratory environment. The TOSRA consists of eight scales.

Sample

The main study involved grade eight students from lower secondary schools in “One District One Dream School” project. One class from each of the 76 schools of “One District One Dream School” project was involved in the study. Data were collected using the Thai versions of the SLEI and TOSRA from a sample of 2,280 students.

Results

Validation and reliability of the SLEI

Internal consistency (Cronbach alpha coefficient) and the mean correlation of each scale with the other scales were obtained for the sample in this present study as indices of scale reliability and discriminant validity. A summary of these values obtained separately for the Actual and Preferred versions of the SLEI is report in Table 1, the reliability coefficients for the different SLEI scales ranged from 0.60 to 0.70 when using the Actual Form and from 0.58 to 0.67 for the Preferred Form when using the individual student as the unit of analysis. On the whole, these results are acceptable although somewhat lower in value than obtained previously in the original validation sample (Fraser et al., 1992b).

The 35-item SLEI was also subjected to a series of one-way analyses of variance. As shown in Table 1, the eta² statistic ranged from 0.17 to 0.20 for different scales. It was confirmed that each scale differentiated
significantly (p < 0.001) between perceptions of students in different classrooms for the sample in this study.

Comparison of students' perceptions of their actual and preferred science classroom environments in the project:

The Actual and Preferred Forms of the SLEI were subjected to separate principal components factor analyses (with varimax rotation) involving the individual student's score. The factor structure that emerged replicated to a large extent the structure reported previously for the SLEI (Fraser, Giddings, & McRobbie, 1992b). From the analyses, the SLEI has been found to be a reliable and valid instrument for assessing students' perceptions of their science laboratory classroom environment, and provides validation support for the SLEI for use specifically in Thailand, in both its Actual and Preferred Forms.

Figure 1 illustrates differences between the Actual and Preferred Forms and indicates that students would prefer more student cohesiveness, open-endedness, integration, rule clarity and an enhanced material environment in their laboratories. In general, students’ perceptions of their preferred classroom laboratory environment in science classes tended to be greater than what they actually perceive is present. This finding supports previous related research in science laboratory learning environments (Fraser, Giddings & McRobbie 1992, Henderson, Fisher & Fraser 1995, Wong & Fraser 1997). The results of this study also indicate that using the SLEI helps Thai science teachers to gain a better picture of the learning environment and the perceived learning needs of their students. It also provides support to the idea that teachers needed to take differences into consideration when planning and designing the science curriculum for the students in the science laboratory environments.

Table 1
Scale Internal Consistency (Cronbach alpha reliability). Discriminant Validity Coefficients (Mean Class Correlation of the Scale with Other Scale) and Ability to Differentiate Between Classrooms (ANOVA results). Scale Means, Scale Standardized Deviation, Variance, and Associations between SLEI Scales (Teachers’ Interpersonal Behaviour) and Attitudes in Science Classes in Terms of Multiple Correlations (R) and Standardized Regression Coefficient (β) for Science Laboratory Environment Inventory (SLEI)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Form</th>
<th>Scale Mean</th>
<th>Std. devia.</th>
<th>Mean diff.</th>
<th>Alpha Relia.</th>
<th>Discri valid</th>
<th>t-test</th>
<th>Eta2</th>
<th>Simple correl. attitu. ( r)</th>
<th>Standa. Regr. Weigt ( β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Cohesiveness</td>
<td>Actual</td>
<td>26.31</td>
<td>4.12</td>
<td>2.87*</td>
<td>0.79</td>
<td>0.38</td>
<td>21.06*</td>
<td>0.17*</td>
<td>0.23*</td>
<td>0.28*</td>
</tr>
<tr>
<td></td>
<td>Prefer.</td>
<td>29.18</td>
<td>3.66</td>
<td>3.66</td>
<td>0.78</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open-Endedness</td>
<td>Actual</td>
<td>20.70</td>
<td>3.66</td>
<td>7.21*</td>
<td>0.74</td>
<td>0.28</td>
<td>43.54*</td>
<td>0.18*</td>
<td>0.23*</td>
<td>0.36*</td>
</tr>
<tr>
<td></td>
<td>Prefer.</td>
<td>27.91</td>
<td>4.23</td>
<td>4.23</td>
<td>0.75</td>
<td>0.37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integration</td>
<td>Actual</td>
<td>23.63</td>
<td>3.94</td>
<td>6.54*</td>
<td>0.71</td>
<td>0.44</td>
<td>31.52*</td>
<td>0.19*</td>
<td>0.25*</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>Prefer.</td>
<td>30.17</td>
<td>4.45</td>
<td>5.45</td>
<td>0.77</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rule Clarity</td>
<td>Actual</td>
<td>23.54</td>
<td>3.87</td>
<td>4.83*</td>
<td>0.72</td>
<td>0.47</td>
<td>42.37*</td>
<td>0.14*</td>
<td>0.22*</td>
<td>0.28*</td>
</tr>
<tr>
<td></td>
<td>Prefer.</td>
<td>28.37</td>
<td>4.59</td>
<td>4.83</td>
<td>0.73</td>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Material Environment</td>
<td>Actual</td>
<td>22.81</td>
<td>4.39</td>
<td>9.06*</td>
<td>0.76</td>
<td>0.42</td>
<td>52.92*</td>
<td>0.27*</td>
<td>0.27*</td>
<td>0.30*</td>
</tr>
<tr>
<td></td>
<td>Prefer.</td>
<td>31.87</td>
<td>5.89</td>
<td>9.06</td>
<td>0.81</td>
<td>0.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Correlation (R)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.65*</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.43</td>
<td></td>
</tr>
</tbody>
</table>

n = 2,280, *p < 0.001
Associations between students' perceptions of their science laboratory classroom environments and their attitudes toward science:

Focusing on the SLEI, the statistical procedures also involved the investigation of associations between students’ perceptions of their actual science classroom environments and their attitudes toward science. The simple correlation values (r) are reported in Table 1, which shows significant correlations (p<0.01) between students’ attitudinal outcomes and science classroom environment on all scales. These associations are positive for the scales of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment scales. That is, in classes where the students perceived greater student cohesiveness, open-endedness, clear rules and a satisfactory material environment there was a more favourable attitude towards their science class.

The multiple correlation R is significant for the SLEI and shows that when the scales are considered together there is a significant association with the Attitude scale. The R2 value indicates that 43% of the variance in student’s attitude to their science class was attributable to their perceptions of their science classroom environments. The beta weights (β) show that in classes where the students perceived greater student cohesiveness, open-endedness, integration, rule clarity, and material environment scales in their teachers, there was a more favourable attitude towards their science classes.

Conclusions

In this study, appropriate statistical procedures were used in order to answer the first research question, regarding the validation of the questionnaires. The procedures included factor analysis, item analysis, Cronbach alpha, discriminant validity and one-way ANOVA. The two instruments, namely, the Science Laboratory Environment Inventory (SLEI), the Test Of Science-Related Attitude are valid and reliable for use in science classes in “One District One Dream School” project in Thailand’s secondary schools.

Overall, Thai secondary school students show relatively favourable perceptions of their science laboratory classroom environments. However, the actual and preferred perceptions of 2,280 students of their science classes in “One District One Dream School” project were measured with the SLEI. The comparisons of the Actual Form with the Preferred Form indicated that students would prefer more student cohesiveness, open-endedness, integration, rule clarity and an enhanced material environment in their laboratories. In general, students’ perceptions of their preferred classroom laboratory environment in science classes in “One District One Dream School” project tended to be greater than what they actually perceive to be provided. With regard to the SLEI, it was found that four of five scales, Student Cohesiveness, Open-
Endedness, Rule Clarity, and Material Environment were positively associated with students’ attitude to science class in “One District One Dream School” project.

This study is very significant because it is one of only a handful of studies in the field of learning environments in Thailand, and it represents one of only a few studies worldwide that has focused on the learning environment at the secondary school level in science classes in “One District One Dream School” project. This study is significant in that, by translating, field-testing, refining, validating, and using the two modified versions of the SLEI and the TOSRA. Overall, the findings of the present study has made severastinctive contributions to the field of learning environments that was one of the earliest learning environment studies to be carried out in Thailand.

Reference


Fraser, B. J. (1991) Test of Science-Related Attitudes (TOSRA) Council for Education Research in Education: Melbourne, Australia


interpersonal behaviour in secondary science classes in Korea. Evaluation and Research in Education, 14, 3-12.


McRobbie, C., Fraser, B. J., & Giddings, G. J. (1991). Comparison of personal and class forms of the science laboratory environment inventory. Research in Science Education, 21, 244-252.


AN INTERACTIVE WHITEBOARD IN THE SINGAPORE CLASSROOM: THE IMPACT ON STUDENTS

Jimmy Seah
Nanyang Technological University
Singapore

ABSTRACT

The use of an interactive whiteboard in a classroom is becoming more prevalent in many schools in UK, Australia and USA (Glover, Miller, Averis, & Door, 2005). There have also been many reports on the positive effects these have on teaching and learning (Smith, Higgins, & Wall, 2005). A study was carried out in Singapore in order to understand the impact of such technology on learning in the local context. Four primary and four secondary schools with two classrooms from each school installed interactive whiteboards. The boards were installed in the classrooms, special rooms and computer labs. For at least two schools, these were installed as replacements for the traditional whiteboard. The teachers for the classes were provided with some basic technical and pedagogical training prior to their use in class. On average, four lesson observations were conducted for each teacher by the research team. Students were interviewed about their experiences with the interactive whiteboard lessons. The presentation reports on how our students have been impacted by the use of the interactive whiteboard in their class for a year.

Introduction

The first Masterplan for the IT in Education focused on the provision of basic infrastructure (computers, laptops, LCD projectors, and network environments, etc.) and training for teachers in the use of Microsoft Word, Excel, PowerPoint and integration strategies in all Singapore public schools. Schools were provided with computers in the ratio of one computer to every five pupils for secondary schools and junior colleges. The ratio for primary schools is one computer to every 6.6 pupils. This paved the way for the second Masterplan, where schools were encouraged to decide on their own development of how ICT could be used for the benefit of their students. (Ministry of Education, Singapore, 2002).

Interactive whiteboards (IWBs) have been around for a while, but until recently the software that accompanied these devices was not specially designed for use in the classrooms for teaching and learning. With the introduction of software tailored for these setting, schools have begun exploring the use of these devices in classrooms.

WHAT ARE IWBS?

Three pieces of equipment work together – a computer, a digital projector and the whiteboard itself which acts as a touch-sensitive screen. In the past, teachers would typically be “hidden” behind the computer monitor or shuttling back and forth between their laptop and the conventional whiteboard. With the IWB, the computer is operated by pointing at or touching the screen, either with an electronic stylus, or with a finger. IWBs can be used to display computer software, CD ROMs, web pages and DVDs. It is possible to edit directly on the board and record changes using an IWB. Video, graphics, and sound can be incorporated and the IWB can be used as an infinite ‘electronic flipchart’.

It has been suggested that an IWB is “more than a computer, a projector or a screen – its sum is greater than its parts” (Miller et al 2001). With IWBs, it is possible to use different software and to access the Internet and other digital resources directly from the screen during a lesson – in short, they act as a ‘digital hub’ (Lee, 2004) for the classroom. Evidence from the UK and elsewhere seems to point to the notion that IWBs offer the potential for teachers to ‘redesign’ their pedagogy (Butler, 2004; Kemeny, 2004; Kennewell, 2004; Lee & Boyle, 2003) While early research claimed that the motivation and novelty of IWBs was due to their enhanced presentational facilities and interactivity, there is, however, a growing understanding of the nature of interactive learning. For example, Glover and Miller’s (2005) analysis of a UK sample of secondary school mathematics teaching with IWBs.

The aim of the “bigger” study was to contribute to an understanding of if and how pedagogy in Singapore classrooms might be ‘transformed’ by ‘informed’ technology integration which placed a greater emphasis on the ‘shifts’ that teachers need to make in their pedagogical practice and the professional development of teachers.
required in this process. This paper however, aims to shed some light on the reaction of the student participants towards the IWBs.

HOW CAN THE IWB BE USED TO SUPPORT EFFECTIVE TEACHING AND LEARNING?

Gage (2006) provides a list of the benefits advocated for IWB use in various “grey” case studies published on the Internet and elsewhere. The following benefits suggest IWBs aid students’ learning in that they:

- allow for lesson to be better structured;
- support collaborative learning;
- help develop students’ cognitive skills;
- help attract and retain students’ attention;
- save time taken up in note-taking or transcribing;
- can provide large, attractive texts and images;
- allow texts and images to be moved around or changed;
- provide additional software which includes a variety of graphics, such as the use of maps, specialist backgrounds and a wide range of images; and
- allow work to be saved and printed.

The IWB can be used in a similar way to the conventional whiteboard, for example to write notes as the lesson progresses. Using the special pen or a finger (depending on the type of board used) it is possible to write on the board. A ‘floating keyboard’ or handwriting recognition tool can be used to input text directly. With an IWB, once each page or ‘flipchart’ is used up, a new one can be opened whilst the previous ones are stored electronically. The IWB usually comes with its own software which makes it possible to create as many new pages or ‘flipcharts’ as are needed during the course of a lesson. Teachers can go back to earlier stages of the lesson if needed and save the pages to use again or revisit with the class (perhaps for revision) at a later date.

The interactive whiteboard can also be used in a similar way to an overhead projector or a PowerPoint presentation to present a series of images or previously prepared ‘texts’. However, the IWB software allows these to be highlighted, annotated or added to on the screen using the pen tools as the lesson progresses. The IWB is a powerful classroom tool in the way that it can be used to represent concepts dynamically. Objects can be rotated, represented as moving objects in relation to one another, and be used to demonstrate change processes.

RESEARCH QUESTIONS

One of the research questions and the one that the presentation reports is: “To what extent does the IWB impact on students’ enjoyment, involvement and satisfaction with their lessons?” The research will attempt to move beyond the collection of quantitative data; which will be perception-based, and to triangulate results with qualitative ones through interviews with students and analyses of videos of lessons observed.

Recruitment of schools

A selected number of schools were identified and invited to participate in the study. Over 20 schools applied to be included in the project. Eventually 4 primary and 4 secondary schools were invited to join. Each school had to identify two teachers; preferably comfortable with the use of ICT (but not considered an expert user) and with good pedagogical practice. The schools chosen acquired and installed the two IWBs late in January 2006; one funded by the Ministry of Education (MOE).

Preliminary survey and lesson observations

A survey was administered at the beginning of the academic year to students to ‘capture’ their attitudes toward the use of ICT, their practice and their experience of its usage in their lessons before their teacher began using the IWBs with them.

One lesson was also observed prior to the use of the IWB. These would serve as a “baseline” for comparison purposes with subsequent lesson observation using the IWB.
Data collection

The data collected during the course of the research included field notes, transcripts of audio and video recordings and other ‘texts’ including the teacher journals, IWB flipcharts and teacher lesson plans. Videorecording in addition to the observation of classrooms and interviewing was undertaken to allow for more detailed analysis as the case studies developed, for example, teacher-IWB interaction, learner-teacher interaction and learner-IWB interaction (Hennessy et al., 2006; Kennewell, 2004) as well as ‘affordances’ (Cox & Webb, 2004) to be enabled which could not be achieved through normal observation. Two cameras were used, one focused on the IWB and the teacher, the other on the wider classroom and students. Unfortunately, due to the technology used to make the videos, analysis using a system such as Studiocode was not possible.

FINDINGS

BECTA (2003) reported that students are motivated in lessons with an IWB because of ‘the high level of interaction – students enjoy interacting physically with the board, manipulating text and images’. Another study found that the scale of the boards enable the visual information to be more easily shared, thereby ‘drawing the class together’ (Levy 2002). IWBs presented the introductory part of lessons so efficiently that more time was freed for ‘interactive activity-based learning’. Glover and Miller (2001) and Walker (2003) reported in their study that pupils were good at listening to each other, and are supportive and encouraging when a class member is at the board. The facility of IWBs to present information in sharp colours, and to annotate, conceal, manipulate, move and zoom in on or focus on images, including text, is also said to enhance the learning process (Dambro, Landato, Marsh, & Rainey, 2000; Levy, 2002).

Levy’s (2002) study had students reporting that their lessons were faster paced, more fun and exciting and this was possibly due to the quality of presentations (Becta, 2003) incorporating large visual images (Smith, 2000) with a more modern or contemporary feel which satisfy the expectations of pupils already immersed in a world of media images (Glover & Miller, 2001). Teachers also felt that pupils were full of anticipation and interest for what would appear next on the board (Levy, 2002). Similarly, teachers in Miller and Glover’s study (2002) felt that pupils’ zest for learning was enhanced by the element of surprise that IWBs and accompanying software bring to lessons. Others suggest that programs used on IWBs offer positive feedback for correct answers (Richardson, 2002), or sound clips to correct or signify repeated errors (Miller & Glover, 2002).

It is claimed that the advantage of IWBs is that they motivate the pupils because lessons are more enjoyable and interesting, resulting in improved attention and behaviour. It is worth noting however that much of the evidence for these observations is anecdotal.

At the time of this writing, only findings from the interviews will be shared. More detailed results will be made available in the final project report.

Video and focus group interviews have found evidence that the impact of display screen technology on the learner includes the following:

- learners show increased motivation and enjoy the interaction the technology offers
- the subject becomes ‘alive’ and captures the attention of learners, and
- it encourages the involvement of learners in the subject.

Some teachers also reported increased student engagement and motivation whenever the IWB was used. When asked how the use of the IWB made them learn better, primary 5 students (aged 11) from one schools had the following comments (I’ve paraphrased for readability):

- The subject was easier to learn because of the following tools: reveal, protractor, world maps, zoom.
- The IWB software made it easy to clean mistakes or do other tasks faster leading to better learning (as compared to a ink-based white board or a chalk board).
- The IWB also played interactive flash movies from www.brainpop.com which makes the lesson more interesting.
- There was more use of pictures and photographs.
- The displays were more attractive with more colours than the traditional whiteboard markers which helps in holding attention.
- The use of “Magic Cubes” – excites the students’ imagination; (“Magic Cubes” refer to an apparent undiminishing number of cubes that was created for one Mathematics lesson). The interactive exercise on the respiratory system.

In brief, they reflect those found in schools from research studies already mentioned. Pupils who had had lessons utilizing an interactive whiteboard for one year felt their lessons were more interesting and engaging. They expressed excitement over the discovery and use of the IWB software’s inbuilt tools like the protractor, the ruler, the count-down timer with sound, and the easy way to change the pen colour or to erase or reset the page.
after annotations had been made. In fact they seemed very competent with the features of the IWB despite having had no formal training.

CONCLUSION

Although feedback from the students was positive; it is nevertheless insufficient to attribute the cause solely to the introduction of the IWBs in the classrooms. One significant factor, this author feels, is the short time frame of the research study. Hence students may have yet to get over the novelty of having a new “toy” in their classroom. In addition to seeing their lesson taught differently, on a number of occasions, they, particularly the primary-level students, get the amusement of seeing their teacher struggle with the technology initially and later became equal “partners” as both teacher and students tried to solve these problems together. It would seem that a longitudinal study may provide a clearer picture of the impact of having IWBs in the Singapore classrooms.

In summary, the results obtained are not conclusive; nor has the research analysis of results been concluded. Many teachers are still grappling with the idiosyncrasies of the IWB and the student’s reactions range from very excited use in the primary schools to a somewhat toned-down excitement in the secondary schools. I suspect this could be due to the maturity of the older students. Students claimed to enjoy the lesson more with the IWB and during the group interviews many were able to offer suggestions of how the IWB could be improved.

REFERENCES


UNDERSTANDING: AN ENIGMA

Nigel Shepstone
Manukau Institute of Technology
New Zealand

ABSTRACT

Many teaching plans for courses in mathematics, science, and technology (MS&T) emphasise the necessity for students to understand the material and to be able to apply the understanding in a creative way. This paper shows that understanding is not a process but an event, by calling on the work of Ludwig Wittgenstein and his ideas on private languages and understanding. It shows that, if Wittgenstein’s ideas are correct, they lead to a number of implications for the teaching of MS&T. In particular, it discusses the environment that is likely to encourage the development of understanding in students and shows that this environment is also likely to encourage creativity in the application of MS&T. Furthermore, this paper presents an approach to the teaching and assessment of MS&T that will improve the possibility of students developing an understanding of these topics. In particular, contrary to modern theories of teaching and learning, it will explain the importance and role of rote learning in building a foundation on which understanding can be developed. Finally, based on the above analysis of understanding and creativity this paper will explain why the teaching of MS&T for understanding is so difficult and how the ideas presented in this paper will go some way to explaining and ameliorating this difficulty.

INTRODUCTION

Usually science and mathematics syllabi emphasise the ideas that students must understand the material covered and be able to use the material in creative ways (for example, Manukau Institute of Technology, 2003). This paper investigates the concept of understanding, and to a lesser degree creativity, and from this investigation draws implications for teaching and assessment.

UNDERSTANDING

Mathematics and science have been taught in various forms for millennia. Plato (1875) has an interesting discussion in the Meno in which he demonstrates how to teach a slave-boy how to obtain a square root. However, as much of the literature on mathematics points out teachers and lecturers have had limited success in developing understanding in their students. In fact a number of articles argue that, over the last few decades, the level of mathematics’ understanding has dropped in the western world (see for example, Mustoe & Lawson, 2002). If educators have not been able to develop a sure method of producing understanding in students, educators must be missing something fundamental about the nature of understanding. There must be something intrinsic to understanding that is not understood!

A perusal of the ERIC database and education journal indices will show that there are many papers and books on understanding mathematics, or understanding physics, or understanding science, etc, etc (for example, see Sierpinska, 1994). However, this same perusal will also show that there is almost no literature on understanding understanding. This is puzzling since one of the main aims of teaching is to inculcate understanding in students (Toohey, 2002).

Again, Plato in the Meno recognises that the concept of understanding is puzzling but does not try to explain it. Locke (1690) skirts around the problem in his An Essay Concerning Human Understanding as does Hume (1748) in his An Enquiry Concerning Human Understanding. Kant does not consider it in his A Critique of Pure Reason or his A Critique of Practical Reason (Kant, 1990a; Kant, 1990b). More modern researchers such as Ryle (1949), Pinker (1999) and Sternberg (1995) do not consider understanding in their respective texts: The Mind, How the Mind Works, and The Human Mind. Roger Penrose (1999) has hypothesised that the workings of the human mind may be linked to quantum effects but this hypothesis has not been tested in any way and is not widely accepted (Pinker, 1999).

One of the few thinkers that has investigated this problem is Ludwig Wittgenstein (1958) in sections 138-42, 151-5,179-84, 191-7 of his Philosophical Investigations. The key insight that Wittgenstein illustrates in these sections is that understanding is not a process but a sudden event. We have all experienced the phenomenon of not being able to understand something, for example an unfamiliar piece of mathematics, however after mulling over it for a while it suddenly instantly becomes clear. This experience shows that this is usually not a step-by-step process but a sudden coup du ciel. What causes this sudden insight is not clear and few thinkers, apart from
Wittgenstein, appear to have examined it. Mason (2003) in his interesting text *Understanding Understanding* does investigate *understanding* but, like Plato and Wittgenstein, does not try to explain this event. Wittgenstein pointed out that the confusion between thinking of understanding as a process and understanding as an event is due to the way in which one talks about understanding. One tends to think of understanding as a well understood process: almost as something concrete rather than a mental state that suddenly arises.

A further facet of this problem is that once we feel we have understood something, such as an unfamiliar piece of mathematics, what is it that justifies us in saying, “Now I understand!” (Wittgenstein, 1958)? It is possible that understanding is part of a set of difficult philosophical problems, identified by McGinn (quoted in Pinker, 1999), such as consciousness, free will, and creativity which may be intractable.

**IMPLICATIONS**

The fact that humankind does not understand what takes place when someone suddenly understands something produces a number of implications for education; such as the following:

**Research into understanding**

It is imperative that research should be carried out into this phenomenon. Firstly to try to determine whether understanding *understanding* is a tractable problem or not; and secondly, if it is a tractable problem, to try to understand the phenomenon and what promotes it and what hinders it. Because so little is known about *understanding* and how it suddenly occurs, it is difficult to elaborate here on the research program suggested.

**Working around the problem**

Although one does not currently understand the phenomenon of *understanding* it is obviously necessary for education to continue without this understanding. Therefore, although *understanding* is not understood, a number of activities may encourage it. If the event of understanding is similar to sudden creative insight the conditions and environment that encourage creativity may help to develop understanding. However, most of what is about to follow is speculative and is not supported by research.

**Teaching to promote understanding**

Inspired by Sternberg’s (1995) list of factors that promote creativity one may, assuming understanding and creativity are analogous phenomena, make the following hypotheses:

Firstly, having well qualified teachers that understand their subjects in great depth probably helps. This may be because teachers who have an in depth knowledge of their subjects can approach the concepts in their subjects from many different, unique perspectives. One of these perspectives may then trigger understanding in a student and the larger the number of “methods of attack” that a teacher can use the greater is the chance that one of them will act as a trigger.

Secondly, a supportive environment will probably aid understanding. This may be because if a teacher understands that he or she does not know what exactly is going to trigger understanding the teacher will realise that it is necessary to be patient and supportive until the event of *understanding* occurs due to the various approaches adopted. In addition, a supportive environment will encourage students to try different solutions to problems and to use innovative means to develop understanding.

Thirdly, it seems reasonable that a student must be well motivated to achieve understanding of the material being taught. Without this motivation it is unlikely that the student will mull over the problem for an extended period of time and try various solutions. Therefore it is necessary for the teacher to clearly justify why it is necessary that a particular piece of knowledge is important and must be understood so that the study itself becomes intrinsically motivating. That is, the student must be convinced that understanding the work is important.

Fourthly, as with creativity, the more prior knowledge, skills, and techniques that a student has in a particular area the more likely it appears that a student will be able extend his or her understanding in that area. One implication that follows from this point is that rote learning, memorising, and learning derivations should not be discouraged because it is possible that a piece of knowledge learnt by rote may trigger the understanding of something more complex. In addition, the new understandings that a teacher is trying to produce in a student must be carefully chosen so that they build gradually on the students’ prior knowledge and skills. This in turn implies that teachers must have an in-depth knowledge of their students’ current level of understanding.

Fifthly, understanding seems to be enhanced in situations where there is social interaction. That is, to understand one must use and discuss knowledge. This point follows from one possible interpretation of Wittgenstein’s idea that *private languages* are not possible and that much social interaction involves
understanding how a language game is ‘played’ in a particular situation (Wittgenstein, 1958). For example, in mathematics a large amount of technical jargon must be known before any real understanding can be developed, that is one must be able to ‘play’ the language game of mathematics in order to understand mathematics.

Finally, in order to understand a difficult topic (and to produce creative solutions to problems) periods of hard work followed by periods of total rest seem to be advantageous.

As Sternberg points out, there is some consensus that the above points encourage creativity but he adds that many psychologists dispute one or more of these points. However, it does not appear as though any research has been carried out to determine whether any of the above consistently encourages the development of understanding.

ASSESSMENT

Often assessments indicate when some concept has not been understood rather than to what degree concepts have been understood. That is, it is very difficult, in a limited time, to determine how well a student has understood all the ramifications of a particular concept but it is usually clear when a student has not understood a concept (Mason, 2003).

If one does not understand understanding fair and meaningful assessment becomes difficult. For example, in a mathematics assessment, it is possible to set standard problems that the students have done previously. Obviously this would not assess the students’ understanding because they may have merely learnt the problems by rote or, at best, have learnt the pattern of the problem by rote and not fundamentally understand what they are doing. In addition, a one-off two or three hour assessment, by its very nature, can assess only a subset of a semester’s work so that the students’ overall understanding of the semester’s work will not have been assessed.

An alternative is to set problems in the assessments that the students have not seen before and that can not be solved by just memorising solutions or patterns of solutions; that is, problems that require a good understanding of the work to complete. The difficulty with this approach is that even good students with a good understanding of the work may not, in the limited time of the assessment, have the sudden insight required to solve some of the problems. This is then likely to prove to be demotivating and damage a student’s confidence with mathematics. Hence the common lament heard from students that they do not like mathematics because it is too hard! In addition, neither of the above two methods of assessment will assess meta-understanding; that is, they will not assess whether the student really understands what the knowledge is used for or its range of applications.

A second alternative is to use a portfolio of work to assess the students’ understanding. This method has a number of advantages and will probably be a more effective measure than more traditional examination type assessments (Arter & Spandel, 1992). However, again there does not appear to be much, if any, research into whether portfolios truly assess understanding or not. This is possibly because it is difficult to measure understanding in an independent unbiased way in order to carry out the research. A further difficulty with portfolios is their administration. It is difficult to keep track of the students’ portfolios during a semester and to ensure that all the work in the portfolio is that of a particular student and not done by the parents or plagiarised (Arter & Spandel, 1992).

CONCLUSIONS

This paper has highlighted the problem of understanding, that is, that it is a sudden event and it is not understood how to consistently cause this event to occur. The result of this is that teaching and assessment become difficult. The paper has also made some tentative suggestions about how teachers can work around this problem in day-to-day teaching and in assessment. However, much more research into this problem is required.

An additional complication pointed out by Mason (2003) is that there are many types of understandings so this problem extends beyond the fields of mathematics and science to all facets of education. It is just that in mathematics and science the problem of understanding is highlighted due to the nature of the topics. That is, with most mathematics problems a student has a flash of insight and solves the problem or does not. This contrast is not so obvious in many other subjects, for example, in writing English essays in which a student may pass with a limited understanding of the topic and not much creative insight. (This comment should not be taken as a disparagement of essay writing. A well written essay requires as much understanding and creative insight as any other form of intellectual activity.)

In the same way that there are many types of understanding there are also many ways of understanding. For example, Olivier Messiaen claimed to understand musical harmony in terms of colour and the mathematician, Ramanujan, is reputed to have understood numbers in terms of feelings (Mason, 2003).

A further complication mentioned by Sternberg (1995) is that in creativity, and presumably in developing understanding, a certain amount of subconscious processing seems to take place before the creative event occurs.
Again, this processing is little understood and by its very nature is hard to examine and measure (creativity, 2006).

REFERENCES


ABSTRACT

Comparatively speaking, the performance of Thai students in international studies of mathematics achievement and related factors has been very poor. While the country did not participate in the 2003 Trends in Mathematics and Science Study (TIMSS), it was placed 36th out of the 40 countries tested in the 2003 Program for International Student Assessment (PISA). This paper reports on a study that investigated the role that Thai mathematics teachers’ interpersonal relationships with their students play in enhancing the students’ achievement in the subject and in forming or changing the students’ attitudes to mathematics. The sample for the study consisted of 1,845 students at year level 8 in 50 mathematics classrooms in schools located in the six regions of Thailand. The Questionnaire on Teacher Interaction (QTI) was validated and administered to identify typical interpersonal behaviour patterns of the mathematics teachers. The Test of Mathematics-Related Attitude (TOMRA) was also administered, thus facilitating an examination of the relationship between students’ perceptions of their teachers’ interpersonal behaviour and their attitudes toward mathematics. It was found that teacher interpersonal behaviour was high on factors such as Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom behaviour, while factors such as Uncertain, Dissatisfied, Admonishing and Strict behaviours were far less prominent. Significant differences were found between students’ perceptions of actual and preferred teacher interpersonal behaviours, and a typology comparison of students’ perceptions of Thai mathematics teachers could be classified as Authoritative in both the actual and preferred teachers’ interpersonal behaviours.

INTRODUCTION

Mathematics is imperative for society’s development, being a discipline that humans can apply to generate new knowledge. For example, topics such as calculus, numerical analysis and trigonometry have enhanced human development, and the subject is the basis of the technology used in science, agriculture, engineering and computing. Aspects of mathematics involve abstract thinking, structure and pattern and universality, thus the subject and the way it is taught and learnt is important and needs to be examined in order to nurture and develop numerate students for the future.

Leary (1957) has stated that the interpersonal behaviour of the occupants of the classroom defines the most important dimension of personality. Wubbels, Brekelmans and Hermans (1987) and Getzel and Thelen (1960) suggested that teacher-student interactions are a powerful force that can play a major role in influencing the cognitive and affective development of students. Wubbels and Levy (1993) reaffirmed the role and significance of teacher behavior in the classroom and in particular how this can influence students' motivation, leading to both their own improvement in teaching and the enhanced achievement of their students. Rickards and den Brok (2003) investigated several factors that affected student's perceptions of their teachers in the United States and the Netherlands – factors that included student and teacher gender, student and teacher ethnic background, student age, teacher experience, class size, student achievement and subject. It was found that not only does each of these variables have a distinctive effect, but also that they interacted with each other when determining students' perceptions.

This research area should hold promise for improving what this researcher has observed regarding the poor teaching of mathematics and the negative attitude of students to this subject in Thai schools. Nakornput (2004) has summarized the report of The Basic Education Commission that examined the results of the Mathematics National Test of grade 9 students in Thailand. The average mark was 41.70% for 2003; 49.88 % for 2002, and 46.95 % for 2001. A report in the Thai Matichon Newspapers (Waisang, 2005) described a survey of mathematics and science achievement in the Trends in International Mathematics and Science Study (TIMSS), conducted on a four–year cycle, with the next data collection round organized in 2007. TIMSS collected data at the eighth grade level to provide information about trends in performance over time, together with extensive background information to address concerns about the quantity, quality, and content of instruction. The TIMSS results highlight the problem with mathematics teaching and learning in Thailand.
Thus the study was designed to investigate students’ perceptions of their teachers’ interpersonal behaviour in mathematics classes in Thailand through the use of an existing instrument, the QTI (Wubbels & Levy, 1993) that was to be first modified and validated for use with Thai students. The study also investigated any associations existing between students’ perceptions of their teachers as assessed by the QTI and the Test Of Mathematics Related Attitudes (TOMRA), the typical interpersonal behaviour pattern of Thai mathematics teachers; what differences if any existed between students’ perceptions of their actual and preferred teacher behaviour, and whether there were any gender differences in students’ perceptions of teacher interpersonal behaviour.

BACKGROUND

The Ministry of Education in 1965 decided that as most foreign countries had changed their mathematics curriculum in Thailand, a mathematics curriculum improvement committee was formed and subsequently drafted a mathematics curriculum for the lower and upper secondary school. This draft curriculum was presented to the Ministry of Education in 1969 and this mixed secondary implementation commenced with a mathematics curriculum similar to the mathematics curriculum draft of 1965. In 1972, the Ministry of Education established the Institute for the Promotion of Science and Technology (IPST) which was to develop science, mathematics and technology curricula throughout Thailand. Thus, as part of its strategic path to economic recovery, Thailand initiated new education sector reforms, which have been supported by a technical assistance project from the Asian Development Bank (ADB) (Fry, 2002).

Thai mathematics teachers base their classroom practices on sound reading theory, provide instruction that meets the specific learning needs of their students, create an organized and stimulating learning environment, and regularly assess their students’ achievement in relation to expectations of the mathematics curriculum. An exemplary mathematics course hopefully covers necessary content, but most importantly offers educators the opportunity to teach students how to use that mathematics content to solve problems, develop innovative designs, think critically, and evaluate options.

The rationale for Thailand’s education reform is that its social and educational development has lagged considerably behind its level of economic development. The 2001 World Competitiveness Yearbook ranks 49 countries on both overall competitiveness and on numerous more specialized indicators. In Thailand, the study of classroom learning environments has taken place only recently; hence there is a paucity of research involving the learning environment in mathematics classroom. The study is significant for at least four reasons. First, two educational instruments from the Western world (the QTI and the TOMRA) were modified, validated and made reliable for use with Thai students, providing extra resources for teachers, educators, and researchers to use in improving teacher-student interactions and hence mathematics teaching and learning in the country. This leads to the second significant outcome of this study: an opportunity will exist for Thai mathematics teachers, educators and researchers to learn more about students’ perceptions of teachers’ actual and preferred interpersonal behaviour which teachers may be prompted to act upon. A third outcome relates to the likelihood of the promotion of more positive attitudes among students toward mathematics, and a fourth outcome is that the study has the potential to provide new information about students’ perceptions of their actual and preferred teacher interpersonal behaviour.

AIMS AND RESEARCH QUESTIONS

1. Is the modified QTI a valid and reliable instrument for use in mathematics classes in Thailand?
2. What is the typical interpersonal behaviour pattern of Thai mathematics teachers?
3. What associations are there between students’ perceptions of their teachers’ interpersonal behaviour as gauged from the QTI, and students’ attitudes to mathematics?
4. What differences are there between students’ perceptions of their actual and preferred teacher interpersonal behaviour?

METHODOLOGY

The purpose of this research was to investigate students’ perceptions of their mathematics classroom environments and teachers’ interpersonal behaviour in lower secondary school classes in Thailand in order to see how knowledge of these factors might be used to improve students’ performance in mathematics. Qualitative and quantitative approaches were used. Quantitative data were gathered with the QTI and the TOMRA. The qualitative approach required students to respond through interviews.
Samples

The sample chosen for this study involved Year 8 mathematics students in the lower secondary government school system. Each student in the sample responded to the QTI (Actual and Preferred Forms) and the TOMRA. The sample consisted of 1,845 mathematics students in 50 classes in 50 lower secondary schools, and the duration of the study extended over the first semester in the academic year 2005. The interview sample consisted of 10% (184 students) of the total sample.

Pilot studies

For each version of the questionnaire, pilot studies were organized using two classes of 79 students and two teachers at the grade 8 level. Interviews with students, assisted in determining the suitability of the questionnaires for the Thai context. Students also were interviewed during the validation process, and tape recordings were made to ensure the accuracy of the translations and to ensure that students’ perceptions of individual items on the questionnaires were accurate.

Actual and preferred Forms

Previous research on classroom learning environment instruments and the approaches to studying educational environments were described while actual and preferred differences in students’ perceptions were explained to compare associations with attitudes. Many of these instruments have also been developed in preferred and actual forms. The use of different forms has enables classes to be profiled from more than one perspective so that intervention strategies can be implemented to improve the classroom learning environments. The role of the teacher on the classroom learning environment was also described.

Students’ perceptions and reactions

Students’ perceptions and reactions to the learning environment may not match the teacher’s responses. Changing the classroom environment to improve students' perceptions can improve achievement as well as outcomes such as interest and motivation (Waxman & Huang, 1996). Fisher and Fraser (1992) explained that the environmental forces that impact on individuals can be described in two ways, either by individuals within the environment or by observers outside the environment. They defined the classroom environment in terms of the shared perceptions of the students, and sometimes the teachers, of that environment. This definition has two advantages. First, it characterizes the setting through the eyes of the actual participants and second, it captures data that an observer could miss or consider unimportant.

The modified QTI and the TOMRA were used to collect data for the study. The QTI measures eight dimensions of students’ perceptions of their teacher’s interpersonal behaviour in the mathematics classroom, namely, Leadership, Understanding, Uncertain, Admonishing, Helping/Friendly, Student Responsibility/Freedom, Dissatisfied and Strict.

The Questionnaire on Teacher Interaction (QTI)

Wubbels, Creton and Hooymayers (1985) developed a model to map teacher interpersonal behaviour using an adaptation of the work of Leary (1957). This model was used in the development of the QTI (Wubbels, Creton, & Hooymayers, 1991; Wubbels & Levy, 1993). This two-dimensional model has been used widely in educational settings (Wubbels, Creton, Levy, & Hooymayers, 1993).
Figure 1. Leary model of interpersonal behaviour (Wubbels, Creton, Levy & Hooymers, 1993, p.15).

Figure 1 (left hand) shows the coordinate system of the Leary model which has been shown to be culturally universal for the types of human interaction measured (Wubbels & Levy, 1991), and Wubbels, Creton, Levy, and Hooymers (1993) have added descriptors for the types of human interactions measured, namely, Influence and Proximity dimensions.

The Questionnaire on Teacher Interaction (QTI) was designed to assess teachers’ behaviour by using students’ perceptions. During the early development of the QTI in The Netherlands, Wubbels, Creton, and Holvast (1988) indicated a desire to investigate teacher behaviour in classrooms from a systems perspective, adapting a theory on communication processes developed by Watzlawick, Beavin, and Jackson (1967). The original version of the QTI was a result of modification, re-wording and reduction of the 128 item from the Interpersonal Adjective Checklist (IAC) (Wubbels, Creton & Hooymers, 1992). The “yes” or “no” response format in the IAC was adapted into a five point Likert-type format.

The original 77-item version of the QTI was first used by Wubbels, Creton and Hooymers at the University of Utrecht in 1987. Their long-term research project was named Education for Teachers. The QTI in the Dutch language was developed after four trials (Wubbels, Creton, Levy, & Hooymers, 1993). In 1991 the QTI was translated into the English language in the USA and used by Wubbels and Levy for cross validation. This American version of the QTI had 64 items and also the eight scales (Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behaviours). Australia was the third country where the QTI was administered by Fisher, Fraser and Wubbels (1993).

Table 1
Descriptions of the Leary Model, Interpersonal Teacher Behaviour for Each Sector

<table>
<thead>
<tr>
<th>Scale name</th>
<th>Labeled</th>
<th>Description on interpersonal teacher behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>DC</td>
<td>…organises, gives directions, sets tasks determines procedures, is aware of what’s happening, structures classroom situations, explains, makes intentions clear, holds class attention.</td>
</tr>
<tr>
<td>Helpful/Friendly</td>
<td>CD</td>
<td>…assists, shows interest, shows concern, is able to take a joke, inspires confidence and trust.</td>
</tr>
<tr>
<td>Understanding</td>
<td>CS</td>
<td>…listens with interest, empathizes, shows trust, is accepting, looks for ways to settle differences, is patient, is open.</td>
</tr>
<tr>
<td>Student Responsibility/</td>
<td>SC</td>
<td>…gives opportunity for independent works, is lenient, allows students to go at their own pace, waits for class to settle down, approves of student activity.</td>
</tr>
<tr>
<td>Freedom</td>
<td>SO</td>
<td>…acts hesitant, apologises, has “wait and see” attitude, is timid.</td>
</tr>
<tr>
<td>Uncertain</td>
<td>OS</td>
<td>…is disapproving, questions suspiciously, looks unhappy or glum, criticises.</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>OD</td>
<td>…gets angry, is sarcastic, expresses irritation, forbids, admonishes, and punishes.</td>
</tr>
<tr>
<td>Admonishing</td>
<td>DO</td>
<td>…keeps a tight rein, checks, judges, demands silence, sets rules, gives hard tests.</td>
</tr>
</tbody>
</table>

Source: Fisher, Fraser and Wubbels (1993)
That later version had 48 items compiled from the eight scales. The instrument’s reliability and validity was established and was reported for Dutch (Brekelmans, Wubbels & Creton 1990), American (Wubbels & Levy 1991) and Australian (Fisher, Fraser, Wubbels & Brekelmans, 1993) researches. The eight sections of the model for teacher interpersonal behaviour for ease of reading presents a description of each scale of the QTI as they appear in Table 1 and Figure 1. Australia was the third country where the QTI was administered by Fisher, Fraser and Wubbels (1993). That later version had 48 items compiled from the eight scales. The instrument’s reliability and validity was established and was reported for Dutch (Brekelmans, Wubbels & Creton 1990), American (Wubbels & Levy 1991) and Australian (Fisher, Fraser, Wubbels & Brekelmans, 1993) researches. Since the development of the QTI, several cross-validation studies have been conducted in the Netherlands, the USA, Australia and Singapore to determine its reliability and validity. The reliability in these studies was measured by the Cronbach alpha coefficient.

![Figure 2. Model for teacher interpersonal behaviour characteristics (Wubbels, 1993).](image)

**The Test Of Mathematics-Related Attitudes (TOMRA)**

A version of the TOMRA was intended to measure students’ attitudes in all subjects, the wording of the items was modified by replacing the word *Subject* with *Mathematics*. For example, an item in the original version, which was worded as “I look forward to lessons in this subject”, was reworded in the modified version to, “I look forward to lessons in mathematics” for mathematics classes. The 8-item TOMRA has a five point response scales namely: Almost always, Often, Sometimes, Seldom and Almost never.

**Students’ interviews**

Interviews are an important data source, and an open-closed interview procedure was used with students in this study. Students were asked for information regarding age, mathematics’ grade in past semester, the behaviour of the teacher, and their views on factors that might help improve their achievement. The interviews made it possible to examine the veracity of students’ perceptions/interactions as they can facilitate an examination of students’ behaviour. The main participants in the interviews were a number of students from the original sample and their responses were recorded. Students were selected at random by researcher, and involved 13-interview questions. After students were interviewed, their responses were translated into English. The interviews were conducted by the researcher and were each of around 30 minutes’ duration. With traveling time to interview sites included, this full-time exercise extended over four months.
Previous research involving the QTI

As mentioned earlier, the QTI has been shown to be a valid and reliable instrument when used in The Netherlands (Wubbels & Levy, 1993). When the 64-item USA version of the QTI was used with 1,606 students and 66 teachers in the USA, the cross-cultural validity and usefulness of the QTI were confirmed. Using the Cronbach alpha coefficient, Wubbels and Levy (1991) reported acceptable internal consistency reliabilities for the QTI scales ranging from 0.76 to 0.84 for student responses and from 0.74 to 0.84 for teacher responses. International research projects utilizing the QTI are well established in the literature (Brekelmans, Wubbels, & Creton, 1990; Creton, Wubbels, & Hooymers, 1993; Fisher, Fraser, & Rickards, 1997; Fisher, Rickards, Goh, & Wong, 1997; Flinn, 2004; Rickards, Newby, & Fisher, 2001; Santiboon & Fisher, 2005; Soerjaningsih & Fisher, 2001; Waldrip & Fisher, 2001).

RESULTS

Validation of questionnaires

For this study, the internal consistency/reliability of the scales of the QTI was measured by using the Cronbach alpha reliability coefficient (Cronbach, 1951). Table 2 provides information about each scale’s internal consistency reliability (alpha coefficient), discriminant validity (using the mean correlation of a scale with other scales in the same instrument as a convenient index) and the ability of a scales to differentiate between the perceptions of students in different classrooms (ANOVA results (eta²)) for the students’ perceptions versions of the QTI when used with the Thai sample. Table 2 indicates that the alpha reliability values for the QTI scales using the students’ perceptions ranged from 0.65 to 0.85 for actual teacher interpersonal behaviour and 0.57 to 0.80 for preferred teacher interpersonal behaviour. The reliability figures are all above the 0.50 level proposed by de Vellis (1991), as a “suggested acceptable level for research purposes”.

Table 2

<table>
<thead>
<tr>
<th>Scale</th>
<th>Form</th>
<th>Alpha Reliability</th>
<th>Discriminant Validity</th>
<th>t-value</th>
<th>ANOVA Results (Eta²)</th>
<th>Simple Correlation Attitude (r)</th>
<th>Standardized Regression Weight Attitude (β)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership Actual</td>
<td>0.71</td>
<td>0.40</td>
<td>12.49***</td>
<td>0.27***</td>
<td>0.47**</td>
<td>0.10***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.73</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Helping/Friendly Actual</td>
<td>0.79</td>
<td>0.40</td>
<td>10.41***</td>
<td>0.28***</td>
<td>0.51**</td>
<td>0.18***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.74</td>
<td>0.38</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Understanding Actual</td>
<td>0.77</td>
<td>0.44</td>
<td>6.04***</td>
<td>0.26***</td>
<td>0.51**</td>
<td>0.19***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.72</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student Responsibility</td>
<td>0.65</td>
<td>0.36</td>
<td>7.29***</td>
<td>0.23***</td>
<td>0.49**</td>
<td>0.16***</td>
<td></td>
</tr>
<tr>
<td>Freedom</td>
<td>Preferred</td>
<td>0.57</td>
<td>0.31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertainty Actual</td>
<td>0.74</td>
<td>0.35</td>
<td>2.08*</td>
<td>0.34***</td>
<td>-0.16**</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.72</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dissatisfied Actual</td>
<td>0.84</td>
<td>0.36</td>
<td>-14.52***</td>
<td>0.31***</td>
<td>-0.14**</td>
<td>-0.01</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.79</td>
<td>0.39</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admonishing Actual</td>
<td>0.85</td>
<td>0.45</td>
<td>-3.56***</td>
<td>0.34***</td>
<td>-0.26*</td>
<td>-0.04</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.80</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strict Actual</td>
<td>0.66</td>
<td>0.18</td>
<td>-0.22</td>
<td>0.21***</td>
<td>-0.02</td>
<td>-0.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferred</td>
<td>0.60</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multiple Correlation (R)

<table>
<thead>
<tr>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.57***</td>
</tr>
</tbody>
</table>

R² = 0.33

N = 1,845, *p < 0.05, **p < 0.01, ***p < 0.001
Internal consistency reliability of the TOMRA

To measure students' attitudes towards mathematics studies, the present study used the Test Of Mathematics Related Attitudes (TOMRA). Using internal consistency reliability, the TOMRA had a Cronbach Alpha value of 0.72 which was considered satisfactory for further use in this study. Both the QTI and TOMRA were used to investigate the associations between students' perceptions of their teachers' interpersonal behaviour and their attitudes toward mathematics. This suggests that the scale was reliable for measuring students' attitudes in mathematics classes.

Associations between students’ perceptions of teachers interpersonal behaviour and students’ attitudes towards mathematics

The simple correlations reported in Table 2 show significant correlations (p<0.01) between students’ attitudinal outcomes and teachers’ interpersonal behaviour on all except the Strict scale. These associations are positive for the scales of Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom and negative for the scale of Uncertain, Dissatisfied, Admonishing and Strict.

The second type of analysis consisted of the more conservative standardized regression coefficient (β) which measures the association between students’ perceptions on each scale of the QTI and their attitudes towards mathematics when the effect of relationships between the scales is controlled. The multiple correlation R is significant for Actual Forms of the QTI and shows that when the scales are considered together there is a significant (p<0.001) association with the Attitude scale (see Table 5.8). The R² value indicates that 33% of the variance in students’ attitude to their mathematics class was attributable to their perceptions of their teachers’ interpersonal behaviour. The beta weights (β) show that in classes where the students perceived greater leadership, helping/friendly, understanding and student responsibility/freedom behaviours in their teachers, there was a more favourable attitude towards their mathematics classes.

Differences between students’ perceptions of their actual and preferred teacher interpersonal behaviour

The scale intercorrelations were calculated to check the discriminant validity shows that these scores ranged from 0.18 to 0.45 when the actual form was used as the unit of analysis and from 0.15 to 0.43 when the preferred form was used as the unit of analysis. It was found that each QTI scale differentiated significantly (p<.001) between students’ perceptions of their actual and preferred teacher interpersonal behaviour classes and that the eta² statistic, representing the proportion of variance explained by the actual and preferred forms, ranged from 0.21 to 0.34.

Figure 4 presents a pictorial comparison of the Preferred Form with the Actual Form based on the Table 2 data, and indicates that students preferred more Leadership, Helping/Friendly, Understanding and Student Responsibility/Freedom behaviours in their teachers, while they preferred less Uncertain, Dissatisfied, and Admonishing behaviours. Actual and preferred perceptions for the Strict scale were virtually indistinguishable.

Students’ interviews

Eight questions from the interview topics covered students’ opinions of the mathematics classroom psychosocial environment. The QTI results were supported by consistent qualitative data from the students’ interviews. Interviewees thought that their teachers were good leaders, friendly, understood and trusted students. Students commented during interviews sometimes that their classroom was not the best in terms of Uncertain, Dissatisfied, Admonishing and Strict behaviours.

CONCLUSIONS

In this study, appropriate statistical procedures were used regarding the validation of the questionnaires. The procedures included factor analysis, item analysis, Cronbach alpha coefficient, discriminant validity and one-way ANOVA. The two instruments, namely, the Questionnaire on Teacher Interaction (QTI) and the Test Of Mathematics Related Attitude were regarded as valid and reliable for use in Thailand’s lower secondary schools. The actual and preferred perceptions of 1,845 students of their teachers’ interpersonal behaviour in mathematics classrooms were measured with the QTI. The comparisons of the Actual Form with the Preferred Form indicated that students would prefer more Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom behaviours in their teachers. However, they would prefer less Uncertain, Dissatisfied, Admonishing and Strict behaviours.
An investigation of the association between students’ perceptions of teachers’ interpersonal behaviour and learning environments with their attitudes to their mathematics classes was carried out. Seven of the eight QTI scales, namely, Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, and Admonishing were found to have a significant relationship with the TOMRA scale, with leadership, helping/friendly, understanding, and student responsibility/freedom scales having a positive relationship. On the other hand, the Uncertain, Dissatisfied, and Admonishing scales were found to have a significant negative relationship with the TOMRA.

REFERENCES


GENDER AND ICT: TOYS FOR THE BOYS OR PEARLS FOR THE GIRLS?

Sarah Snell and Catherine Snell-Siddle
Universal College of Learning
New Zealand

ABSTRACT

The information and communications technology (ICT) industry is becoming increasingly recognised as a male domain. Enrolment figures and trends on tertiary programmes of study at New Zealand Polytechnics also reflect that women are participating less and less in the ICT discipline. Other literature suggests that this trend of low female participation could be linked to gender and occupational stereotypes. Societies and cultures all to some degree have stereotyped beliefs about career choices and paths for both males and females. Educational training decisions that females make can be influenced by this occupational stereotyping. Many educators are expressing concern in relation to female participation and some efforts are starting to be made in terms of offering scholarships and special training programs specifically targeted to women. This study examines why females are participating in ICT at a declining level and presents strategies as to how this imbalance can be addressed. For example, one strategy trialled with a group of female secondary school students involved a one day ‘boot camp’ at a tertiary institution. This paper describes this initiative and provides feedback from participants.

INTRODUCTION

Males and females have traditionally gravitated to certain occupations within our societies for a variety of reasons. Our changing society is now affecting on how we view the relationships between men and women and what is male or female work. This paper provides a discussion on why females are participating in ICT at a declining level and attempts to provide an insight into how this low participation can be addressed. Research data gathered in 2004 is summarised to provide a basis for the subsequent pilot that has been carried out. A trial strategy, conducted in 2007, is described along with results and feedback from participants who took part. The paper culminates with a discussion of areas for further research and direction.

BACKGROUND

During 2004, an explorative, descriptive study was carried out to examine the gender imbalance associated with students studying information and communications technology (ICT) within the polytechnic tertiary sector in New Zealand. The study aimed to investigate reasons for the lack of females undertaking tertiary study in information technology (ICT) in the New Zealand polytechnic sector. This was achieved by gathering a range of perspectives and perceptions from students currently studying at polytechnics within ICT or non-ICT based programmes through the use of focus groups. Data was also gathered via statistics on female enrolment figures and perspectives from institutions offering programmes of ICT study within the tertiary polytechnic sector. The results from this data collection appeared to be similar across each institution with a downward trend of female enrolments from 2000 to 2005, clearly showing an imbalance of males to females in each institution. Two focus groups where formed with the first consisting of six male participants who were currently studying within ICT – on the Bachelor of Information and Communications Technology (BICT) at UCOL. This group focused on male perspectives on female participation within IT. The second focus group consisted of six females who were studying both within ICT (on the BICT programme) and those that were studying at tertiary level but not in IT (studying the New Zealand Diploma in Business). This group focused on female perceptions and reasons for either considering IT as a career choice or not. Of these two focus groups undertaken, lack of ‘interest’ was the most common theme emerging in response to questions asked in relation to perceptions of female participation in the ICT industry. Another common theme was ‘direction’. Below are some of the quotes made in the focus groups concerning female participation with IT:

“No, I never considered working in IT – I like fresh air, moving around and talking to people – computers are none of those things”

“Females are more interested in soft, arty, caring careers”.

“IT is geeky”.

“Interest levels of females and males are different”.

“Females are computer users, not techies”.

“Teachers are not aware of the industry as it was not an option when they were young”.

485
“Many teachers in schools are self-taught hobbyists (at best) and have no concept of what the IT industry can offer. Schools are required to show viable career paths – I do not believe schools do this in IT”.

“Schools don’t understand the ICT industry and the careers that are available – therefore marketing is a big problem”.

“Make it clear that the IT industry is not all about hardware and can choose different avenues to follow”.

“Use role models or profile past female students to promote”.

“I think possibilities for career opportunities need to made clearer”.

“There was never any promotion on IT at school when I was choosing a career path to go down”.

All participants agreed that little advice or direction regarding ICT was given at school. Most participants agreed that it is not clear as to what career opportunities are available or what job tasks the IT industry offers. Even though women now constitute the majority of those participating in higher education overall, the concentration of learning that these women are participating in, is in traditionally female fields such as education and health.

Why should a study of female participation in the ICT industry be of interest? The management literature indicates that the main benefits are the creation of opportunities for competitive advantage. Clearly computers and information are at the leading edge of change in our society and therefore if the general arguments advanced for competitive advantage hold, then failure to achieve gender diversity in the ICT industry will affect all societies. Arguments to support this view cover areas such as cost benefits, enhanced flexibility, creativity, resource acquisition, marketing, and problem solving abilities (Davidson & Griffin, 2003). Barker and Aspray (2006) support this view stating a variety of reasons for why it is important to increase female representation within the ICT industry. First, increasing the qualified labour pool within the ICT sector will increase the capability to drive innovation and product development. Second, with ICT often having favourable working conditions and higher pay scales, if more females engage in this industry, then more opportunities for financial well-being are created, which is beneficial to the population as a whole. Third, they reiterate the argument for a diverse workforce stating that companies cannot compete against each other if all are not recruiting from a country’s entire pool of talent, and that if an industry ignores 85 percent of available talent, then that company is reducing its ability to perform to its best standard.

Grainger (1992) suggests that this trend of low female participation within ICT could be linked to gender and occupational stereotypes. Societies and cultures have stereotyped beliefs about career choices and paths for both males and females. Educational training decisions that females make can be influenced by this occupational stereotyping. From a very young age, women can be steered into traditionally female subjects, which can have a direct influence or effect on career choices or training opportunities later in life (Grainger, 1992). Teague and Clarke (1995) stated that even though computers are widely available in the workplace, schools and home statistics show that computing still appeals more to males than females. They discuss studies of abilities that demonstrate there are no gender differences in computing ability or achievement, and that when females do participate in computing programmes they perform just as well as their male counterparts. They believe that differences in gender participation and interest in computing arises directly from the way computing is offered in schools and that this facilitates the development of gender oriented perceptions in relation to computing. Young (2000) considers that teachers’ attitudes toward technology directly correlate to the gender imbalance and the perception of computers as a male domain. O’Keefe (2004) supports this view saying that much of the gender problem lies in schools where few teachers are aware of what a career in IT means. Shashaani (1994) suggests that with the existence of this gender gap there is little reason for optimism that women’s participation in this field will increase in the future. She outlined how many educators are expressing concern in relation to female participation and that some efforts are starting to be made in terms of offering scholarships and special training programs specifically targeted to women. Her research showed that the basis of gender differences in attitudes toward computing was mostly based on social and cultural influences rather than having any connection with innate ability. Her findings indicated that there were significant gender differences in computer interest, computer confidence and gender-stereotyped perceptions, all swaying toward male dominance. Her data also revealed that there was a strong correlation between positive parental encouragement and the participation of both male and female children in computing studies at school. Children who reported that parents had shown positive attitudes to computing and IT related fields, felt more confident and interested in computing in general.

O’Keefe (2004) believes that barriers against women entering the IT industry are based on perceptions. He described a major perception as “IT is either about gaming or sitting in dark corners eating pizza and coke and programming for hours and hours and you never talk to anybody” (p. 8). He believes that it is beneficial to use females who are working within IT to speak to other women in an attempt to dismantle misperceptions and to
raise awareness. Thorp (2004) agreed with this concept when she suggested that students often have problems when trying to name role models, be they either male or female, within the IT industry. She believes that mentoring programmes to promote females who are associated with IT could be the answer. Rudman (2002) supports this view outlining that without role models and mentors, support and positive encouragement, barriers are raised by individuals themselves based on upbringing, perceptions and socialisation experiences. To challenge and change perceptions, clear guidance needs to be provided in regard to career options and roles that can be carried out within the industry. Cohoon and Aspray (2006) describe a role model as “a person who serves as an example of the values, attitudes, and behaviours associated with a role” (p.156). They believe that if you can see someone who is socially similar to yourself in a particular role the more likely it is that you will consider a similar role for yourself. In an article published by Martin (2002, ¶11), Cherry Vanderbeke, general manager of Gen-i’s software solutions says “Girls don’t realise the variety of roles within IT” and that “it is more than just programming. There’s a whole range of other roles like project management, business consulting and systems architecture”. These people-oriented jobs are generally more appealing to women, who often have the interpersonal skills to do well in them. In the same article, Deannah Templeton a senior consultant says that schools, universities and IT companies fail to communicate and portray the industry’s diversity to girls. As part of a development strategy to encourage more women into ICT and to challenge current perceptions, the authors developed and trialled an ICT workshop at the Universal College of Learning (UCOL) in Palmerston North, New Zealand in July 2007.

TRIAL STRATEGY – CAMP TECHETTE

This workshop was developed with an aim to provide a group of 22 secondary school girls with an opportunity to participate in hands-on ICT activities and also gain clear guidance on career opportunities and roles available within ICT. To assist with this, females working within the industry were recruited to act as role models and to speak about their roles and career paths within the industry. These role model sessions included discussions on how they began their career in the industry and what influenced their choice; what education they may have undertaken; any barriers they have faced; what working in a male dominated industry is like; and finally any advice they may have for girls/women choosing a career in the industry. The practical activities included a networking activity carried out in a dedicated computer hardware laboratory, with an afternoon session on an animation multimedia activity. Female students currently enrolled on the Bachelor of Information and Communications Technology (BICT) also came to speak to the girls giving feedback on their current experiences and expectations for the future.

RESULTS AND FEEDBACK

Questionnaire

A main aim of the day was to provide an insight for participants into the options and possibilities of a career in ICT. After the workshop, questionnaires were sent to the girls via their computer science teacher who also accompanied them on the day. All 22 participants provided feedback. This questionnaire asked for feedback on different aspects of the day, along with whether the girls felt more informed about opportunities within the industry, and if they would consider a career in ICT as a result of the workshop. The following comments provide feedback from participants’ responses to a selection of these questions.

After attending the day at UCOL, did participants feel more informed on the roles and career opportunities available in the ICT industry? Eighteen responded yes, with three unsure.

“I now have more information on what sort of careers in IT are available”
“it was good to hear from people in the industry and to be able to ask questions”
“we got to see real applications of ICT work from the speakers. There were also posters and information throughout the day on opportunities”
“yes I feel a lot more informed, the speakers gave me a realistic idea and the exercises helped with different things involved in ICT”
“able to ask questions and receive answers from people in the industry”
“now I know what other careers you can do in the ICT industry”
“I know more about what IT careers you can choose and different courses that you can take. Also the market out in society for IT professionals”

487
When asked, as a result of attending the day at UCOL, if they would consider a career in the ICT industry, the following selection of responses resulted. Six indicated yes to this question, ten unsure, and two responded with a no.

“lots of jobs available, opportunity to earn a high salary, enjoyable environment”
“I’ve always been interested in a career in ICT but now I have to think about what field”
“it sounded like a fun, interesting career to take. I was already considering it, but after attending the day at UCOL decided it was definitely what I wanted to do”

When asked to provide any other comments, all feedback was positive and overall they seemed to enjoy the day.

“I thought it was a great idea and had an awesome time”
“it was fun, thanks heaps, I hope you continue this in the future”
“it was a very good experience thanks”
“thanks for great day, I enjoyed the time I was there for”
“I really enjoyed that day and discovered many new things”
“thank you”
“thanks for the great opportunity”
“it was good thanks for the opportunity”
“thanks heaps for the opportunity to hear the ideas of women who were in this industry”
“I thought it was a cool thing to go to UCOL because other schools don’t get to go on trips to UCOL”
“I think the lecturers seem like really nice, fun people to learn from”
“overall I had a good time and I believe the rest of the class did too”
“I just wish that these kind of workshops were available in other subjects because I definitely found them worthwhile”

Researcher observations

Throughout the day, the researchers made observations on the participants behaviours during different activities. All appeared to enjoy the day providing positive feedback on all aspects of it. During sessions with speakers from industry, the participants showed high interest in regard to the possibilities that a career in ICT can provide. Many questions were asked based around the following topics: what a typical day would entail; how many people a day do they talk to; what kind of businesses do they deal with; can they work from home; are their opportunities to earn large salaries; and what is it like mainly working with males? The speakers provided excellent responses to all questions asked. They provided illustrations of their typical working days presenting examples and scenarios from which the students could gain an understanding of the types of roles and responsibilities carried out.

As this workshop was a pilot, the authors wanted to know if there was anything that could be included or improved for future iterations. The following comments were provided by the participants:

“meet more current students - possibly talking to/listening to actual students that are currently part way through their courses”
“HTML design and graphics”
“I think it would be good if we could spend more time in the workshops”
“more creative and technical”
“more on the web design industry”
“more practical aspects”
“more practical time. Complicated things to do with / on a computer”
“maybe more on the separate definitions of different areas in IT”

CONCLUSION AND FUTURE DIRECTIONS

It is clear that women are becoming or remain increasingly under-represented within the Information and Communications Technology industry although it is evident that women have a significant contribution to make within this discipline. Female role modelling has been identified as an excellent way to encourage females into ICT in both education and the industry itself in order to dispel many of the misperceptions about the industry.
Literature indicates that there is a perception that computing is considered a male domain even though there is no evidence of any difference in ability with regard to females and males performance in this area. It is suggested that much of this gender misconception stems from both parents and schools, and the way individuals are socialised at a very young age. Even though women now constitute the majority of those participating in higher education, the concentration of learning that these women are participating in is in traditionally female fields such as education and health.

Work around female representation and role modelling is intensifying but more work is still required in this area to increase awareness of the types of work roles and career opportunities being carried out by both males and females in the IT industry. Feedback on the workshop was extremely positive. Results indicated that participants felt more informed on the roles and career opportunities available within the ICT industry after attending the day. Six participants of the 22 that were present felt that as a result of attending the day, they would now consider a career in the ICT industry. Further iterations of the workshop trialled in 2007 are to run in 2008 and will be extended to include other secondary high schools. Suggestions provided by the 2007 workshop participants will be incorporated into a revised schedule of the day and the workshop may be extended over a two day period.

REFERENCES


Teague, J., & Clarke, V. (1995). *The failure of the education system to attract girls to formal informatics studies*. In D. Watson & D. Tinsley (Eds.), *Integrating Information Technology into Education* (pp.229-238). Great Britain: TJ Press Ltd.


MOBILE TECHNOLOGIES: ENHANCING POSSIBILITIES FOR LEARNING

Sarah Snell and Catherine Snell-Siddle
Universal College of Learning
New Zealand

ABSTRACT

Technology is changing the way education is being delivered particularly within the higher education arena. Increased access to this technology means that educators need to incorporate new methods of delivery in their teaching. People are becoming lifelong learners engaging in learning opportunities when and where they choose based on need and availability rather than being limited to physical location. It is important to find new ways to integrate emerging technology into current learning practices and training programmes for current educators. Educators need to commit to change and understand that they need to move with emerging technologies to ensure they are attracting, engaging and retaining learners. This paper will describe current mobile technologies available and how some of these tools are being used in education in New Zealand. Further research initiatives to be carried out will also be discussed including a trial using mobile devices to three target groups of students made up of online web based learners, distance/blended delivery resource based learners and traditional face to face classroom based learners. In one of these initiatives a learning environment instrument will be used to assess ‘actual’ and ‘preferred’ perceptions of the usefulness of mobile devices allowing comparisons between groups and predictions for possible future uses of mobile tools to be made.

INTRODUCTION

This paper will examine the use of mobile technologies and their ability to enhance the learning experience through mobile learning. It will also give an overview of existing learning environment instruments that may be appropriate for the intended study. An outline of a trial to be conducted at the Universal College of Learning (UCOL) using mobile devices will be provided. UCOL is a tertiary Institute of Technology in New Zealand consisting of three regional campuses with a population of 6,000 (equivalent full time) on and off campus students. UCOL wishes to use new technologies to enhance its focus on developing student independence, self-reliance, and self-motivation. Recent research suggests that current UCOL students use technology extensively both at UCOL and at home. In the future they want better technology supplementing face-to-face contact with lecturers and fellow students. The students believe that learning in the future will be more led by technology and while they support that direction the need to maintain face-to-face contact is seen as important. The introduction of mobile technologies as a supplementary tool to support learning will meet these expectations (eLearning Project Team, 2006).

BACKGROUND

Mobile technologies and mobile learning (m-learning) are gaining popularity with wireless devices that can be used by students to access web servers for real time information from anywhere on or off campus. Mobile learning has an advantage of ease of access over the use of activities such as accessing learning management systems which rely on a computer terminal to interface with the learning material (Mellow, 2005). Mobile devices are anything that is handheld with wireless capabilities in which real time learning with no fixed location or time can occur. This includes devices such as mobile phones, portable digital assistants (PDAs) or Palmtops and iPods (Mellow, 2005).

“Mobile devices are a key feature in many activities carried out by young people: making arrangements, passing on information, passing on gifts in the form of jokes or graphics, sharing and comparing ring tones, texting each other using a still developing new language” (Colley & Stead, 2004, p.45). These devices are now ubiquitous in society with a large majority of students using mobile phones - at the start of the 2005 university year at Auckland University of Technology, 82% of students reported owning one (Mellow, 2005).

Kossen (n.d.) makes the following statement which encompasses the benefits and power of m-learning: “A key benefit of m-learning is its potential for increasing productivity by making learning available anywhere and anytime. Because mobile devices have the power to make learning even more widely available and accessible, mobile devices are a natural extension of e-learning. Parsons and Ryu (n.d.) point out that “although in some cases m-learning is seen as simply an extension of e-learning, just another channel for delivering the same content, in fact quality m-learning can only be delivered with an awareness of the special limitations and benefits of mobile devices” (p.1).
Rickards (2003) points out that technology-based futures in education have several issues of certainty – “they will always be linked to the technology that is currently available, which in turn will be partly driven by what people want to use technology for” (p.121). There is enormous potential in the use of technologies such as PDAs, mobile telephones and MP3 players to enhance the learning experience.

Uses of mobile technologies in education

Much of the literature on mobile technologies speaks of these tools being used as additional or supplementary tools in which to enhance the learning process, often with particular reference to processes such as exam preparation and lecture reviews. ‘Chunking’ of data is particularly suited to mobile devices because of their screen sizes and storage capacity. Learning material is divided into bite size knowledge chunks that can represent essential summarised data that can be used by learners to assist in learning challenging concepts, review material covered in previous classes or as an overview to upcoming lectures. This concept of delivering ‘pieces’ of information rather than entire blocks of learning material means that m-learning is well suited for enhancing the learning experience rather than being a primary method of delivering courses. Mobile learning provides another layer of support to the student’s learning experience (Mellow, 2005).

There have been a number of published pieces of work outlining ways that mobile devices have been used within the education environment, both internationally and in New Zealand. In the United Kingdom, Attewell and Savill-Smith (2005) conducted an m-learning project in which mobile devices were used to provide literacy, numeracy, and life skills learning experiences for young adults. The project explored whether the enthusiasm young adults hold for wireless devices, such as mobile phones and portable entertainment devices can be harnessed and redirected to encourage participation in education and training, in this case literacy and numeracy training. The approach of the m-learning project was to offer small sets of learning experiences on these mobile devices. The study also included a review of the types of activities that have previously been trialled for different mobile devices. Mobile phones were seen to be suited to sending text messages to students reminding them to study for exams. Additionally they were used for quizzes, picture and sound messaging using multimedia text messaging services (MMS) and word and phrase translations. Research into PDAs or palm computers indicated that the distinction between these and mobile phones is becoming less and less obvious. There are a number of hybrid phone-palm devices that include both phone and palmtop functionality. The types of use reported on include science field work for the collection and analysis of data, medical education using them for reflective logs and learning games.

Attewell and Savill-Smith’s (2005) project showed that using high tech tools such as mobile devices is an effective way to attract, motivate and retain non-traditional learners in education and training that they might not otherwise have engaged in. A major finding of this research project, which has implications for institutions wishing to incorporate such delivery techniques, is that a significant amount of training needs to take place for those facilitating the learning to ensure they have both the technical ability and confidence to use the tools and delivery approach in an effective manner.

In another UK study, Colley and Stead (2004) describe a project in which they attempted to meet the challenge of producing a set of innovative games, material and activities for use on mobile devices to enhance maths and English skills. The two platforms trialled were mobile phones and PDAs. Mobile phones were selected as the primary platform as they are the communication tool of choice for most young people and are relatively inexpensive unlike PDAs where cost is still an issue. The authors did however also note that the lines between mobile phones and PDAs is becoming blurred as more and more are starting to combine their functionality. An advantage palmtops have over mobile phones is their screen size and ability to store and process larger amounts of data. As in Attewell and Savill-Smith’s (2005) project, Colley and Stead (2004) talked of the challenge of designing content that can stimulate learning using a small platform such as a mobile phone. Small themes of content such as themed quizzes were designed with this in mind that linked to relevant curriculum topics.

A project using cellphones as the mobile tool for learning has been trialled in 2005 in New Zealand. This project used a system called StudyTXT led by Dr Peter Mellow from Auckland University of Technology. StudyTXT is a mobile phone on-demand study support system. Students can access ‘knowledge bytes’ of information about a particular subject they are studying and review them in their own time. This model poses as a modern incarnation of the traditional flash cards often used for study. The project came about due to resistance from students to use traditional forms of flash cards for study. The lecturer had created paper based PowerPoints, printed and added them to card for students to review. Feedback from students indicated they would not use this type of medium for study in places such as ‘waiting for a bus’ and that ‘it was not cool to be seen to be obviously studying’. To overcome this resistance, Mellow (2005) designed the StudyTXT system to include key content to fit with a form of technology the students were comfortable with. Students could then ‘snack on their study’ when they felt inclined to do so. Initially StudyTXT was considered a content delivery system based only around rote learning methodologies, however ways to make the system more interactive have been created to involve principles of constructivism. An example of this interactivity was given in the paper.
outlining law as the topic. An argument for a certain case was presented in a lecture and a following text message would contain scenarios it could be applied to. The student would then have to think about how they could apply the same argument in other cases presented via their mobile phone.

In New Zealand, the University of Auckland Business School was awarded a grant by Hewlett Packard in 2003 to explore and develop the application of mobile technologies in learning environments. The findings from the research, being conducted through the Business School’s Centre of Digital Enterprise (CODE), are expected to have major implications for the design of future educational programmes (Centre of Digital Enterprise, 2006). CODE Director, Professor Ananth Srinavasan, says: "Everybody knows that 18- to 24-year-olds are huge users of mobile technologies, particularly text and picture messaging. By exposing these techno-savvy students to the latest in applied mobile technologies, we expect to get a better understanding of how these could be used to gain value for universities, schools and companies" (The University of Auckland Business School, 2005, ¶3). Another member of the research team adds: "Few people have offered training and advice for staff and students to get the best out of new technologies and promote best practice. Even fewer have followed this up to find out if either the technology or the training had made an impact. This is exactly what we plan to do. The HP grant will fund the new technology we want to use and also help to support the research" (The University of Auckland Business School, 2005, ¶5).

**Learning environment instruments**

From a review of the learning environment literature, there does not appear to have been any studies using an existing instrument to assess the effect that mobile technologies might have on the learning environment. The Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) and the Web-based Learning Environment Instrument (WEBLEI) are two instruments that have been identified by the authors as having potential, with modification, for application in the proposed trial.

The development of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) by Aldridge, Fraser and Fisher (2003) drew on the What is Happening in this Class (WHIC) questionnaire. The development and validation of this instrument was considered important as it was seen as a “widely-applicable and distinctive questionnaire for assessing students’ perceptions of their actual and preferred classroom learning environments in outcomes-focused, technology-rich classroom learning settings” (Aldridge, Fraser & Fisher, 2003, p.175). TROFLEI measures the following 10 dimensions of the actual and preferred classroom environments at high school level: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity, differentiation, computer usage and young adult ethos (Aldridge, Fraser & Fisher, 2003).

The Web-based Learning Environment Instrument (WEBLEI) was developed by Chang and Fisher (2003) to gather quantitative data on students’ perceptions of their web-based learning environment in a tertiary environment. The WEBLEI uses the following four scales to measure students’ perceptions: access, interaction, response and results. Chang and Fisher’s (2003) study found the instrument to have factorial validity and the WEBLEI scales to have acceptable reliability and discriminant validity from a statistical perspective.

From the initial design, the WEBLEI was modified by Chandra and Fisher (2006) to use in a blended environment involving high school students. Although the items were amended or changed to suit this different environment, the total number of items and number of items per scale were similar to those in the original version of the WEBLEI (Chandra & Fisher, 2006). Chard (2006) selected the WEBLEI as a suitable instrument to study online learning environments in her study of tertiary students involved in mixed mode delivery as it is targeted for web-supported and web-based learning environments and is designed for a tertiary environment. WEBLEI was also considered to be the most appropriate instrument by Chard as it is designed to measure learning effectiveness that includes access to materials, interaction, students’ perceptions of the environment, and students’ determinations of what they have learned (Chang & Fisher, 2001, cited in Chard, 2006).

**RESEARCH INITIATIVES**

The authors are planning a trial using mobile devices at UCOL. The choice of which mobile devices to be used has not yet been defined. The college is committed to providing e-learning opportunities which have six guiding principles. These are to ensure its teaching and learning approaches are accessible, supported, pedagogically sound, student-centred, sustainable, and collaborative. Three modes of delivery have been proposed to cater to on-campus teaching, cross-campus teaching, and off-campus teaching. The first is a supplementary mode which is mainly face-to-face with an optional online component. The second is mixed mode which integrates face-to-face and online components, with the third being a fully online mode consisting of distance learning using online plus text, audio, and video. The intended study will target all three modes of delivery and student groups.

The purpose of the study is to investigate how the learning environment can be enhanced through the use of mobile technologies in order to enrich the student learning experience in a tertiary environment. The overall objectives will be to modify, validate and apply a learning environment instrument to assess ‘actual’ and
'preferred' perceptions of the usefulness of the mobile devices; and to assess both student and teacher perceptions (as personal rather than class forms).

METHODOLOGY

The research approach to be taken will contain mixed paradigms. The quantitative data will be gathered using an empirical approach utilising a learning environment inventory in which scale items will be classified and coded. Qualitative data will be obtained using an interpretive approach through the use of interviews and focus groups which will aid in validating the learning inventory. The study is to be a collaborative project where different target groups of students will be investigated and reported on by each of the researchers and comparisons made. All students enrolled in the courses being trialled will be included in the study and no differentiation will be made on the basis of culture or age. The sample group will be divided into three distinct groups:

- Online students (web based learning): 200 +
- Distance/Blended Delivery students (resource based learning): 1000 +
- Traditional face to face students: 100 <=

The researchers will develop and administer the learning environment instruments, conduct interviews with teachers and students and analyse and report on results. Teachers will be asked to be active participants using the mobile tools with identified student groups. They will also be invited to provide feedback via interviews. Students will be asked to provide feedback via questionnaires, and some will be invited to participate in focus groups and interview sessions.

Quantitative methods

A learning environment inventory questionnaire will be developed by modifying an existing instrument. It is envisaged that WEBLEI will be suitable to gather students' perceptions of their learning environment with the addition of attitudinal and cognitive scales. Once developed, the learning environment inventory will be assessed for content validity and reliability. Student perceptions on effectiveness and usefulness of the mobile tools used will be assessed using actual and preferred forms of the inventory.

Qualitative methods

Semi structured interviews and focus groups will be carried out to obtain feedback on the differences between the actual and preferred data collected from the questionnaires. The qualitative information will be used to augment patterns identified through statistical analysis of quantitative information (e.g.; differences between male and females perceptions).

The scale items on the learning environment inventory and interpretations of those scales will be assessed for reliability and validity. Cronbach alpha test will be used to measure consistency, with an aim of achieving 0.6. If necessary, the scale items will be edited. Responses from interviews will be used to assist with validation of interpretations of scale items. Actual and preferred forms of the questionnaire will be analysed for perceptions on usefulness of mobile technologies along with attitudinal and self-efficacy perceptions.

FUTURE DIRECTIONS

The trial will enable enquiry into the following research questions:

- Is the learning environment questionnaire developed a valid and reliable instrument for use in New Zealand?
- Does the use of mobile technologies enhance student outcomes?
- What sort of learning environment is created by mobile technology tools?
- What associations exist between students perceptions of their learning environment and their attitudinal and cognitive outcomes?
- What differences are there between the actual mobile technology learning environment and that preferred by students?
- Are there differences between how each of the three target group utilised the tools?
- Does age and gender affect student’s response to using the tools?
- Are there differences between each target group’s results in relation to student outcomes and preferences?

CONCLUSION

The study of improving the learning experience through the use of technology is a growing area of research. The emergence of this research domain has developed from the most basic of technologies such as chalk and paper, to the most advanced technologies that are used widely by today’s learners. Mobile devices are gaining popularity as they enable learners to access real time information anywhere and anytime without having to
interface with a computer terminal. Educators are endeavouring to connect with learners through mobile tools which are becoming integral to many people’s lives, hence an excellent way to try to engage with learners in a non-traditional manner. Rather than being a sole delivery method, mobile learning aims to provide another layer of support to the students’ learning experience alongside other delivery methods to enhance and support the learning process. The use of mobile technologies will require effective, multi-skilled and enthusiastic teachers to manage the learning environment. The proposed study intends to trial the use of mobile devices and to provide validation of a modified form of an existing learning environment instrument for assessing the use of mobile technologies in an m-learning tertiary environment in New Zealand. Efforts to assess this exciting and new learning environment by using, and modifying a currently developed instrument, will make an important contribution to the work completed thus far.

REFERENCES


eLearning Project Team. (September, 2006). Background paper for elearning strategy: A synopsis. UCOL: Palmerston North.


WRITING CHEMISTRY AND THE FOUR SKILLS: AN ONGOING PROCESS

Steven Graham
Udon Thani Rajabhat University, Thailand

ABSTRACT

This study recounts the process undertaken to produce English language teaching materials for chemistry majors at Udon Thani Rajabhat University. Initially, a writing course was requested for third year students for one semester and later the Language Center decided to produce an integrated skills course focusing on listening, speaking, reading and writing for possible future use. Last semester, the third year chemistry students attended a second course; as a consequence, this presented the Language Center with the possibility of trialling various sections of the new integrated skills course. This semester the new course participants are participating in the final pilot course which has been extended by a further sixteen hours.

KEYWORDS ESP; chemistry; four skills; materials

INTRODUCTION

The students attending this course are chemistry majors and the Language Center at Udon Thani Rajabhat University was initially tasked with designing a writing course consisting of sixteen weeks of instruction of two hours per week, totalling thirty two hours. After two of these courses were completed, the Science faculty who are responsible for the students, requested that the course be extended by a further sixteen hours and that it was to incorporate the four skills.

Graham (2007) detailed the initial systems, frameworks and components that made up the first writing course and gave insight to what might be expected during the piloting of the expected courses. This is the second of what will inevitably be a trilogy of papers describing the processes undertaken to prepare an integrated skills English language course for chemistry students.

What is important to emphasise at this juncture, is the fact that the aim of the course, as detailed in the previous paper, is to teach English and not chemistry and must not be confused with education approaches such as Content and Language Integrated Learning (CLIL), namely the teaching of content and the simultaneous learning of a foreign language (Roldan Tapia 2007). In truth, as the pilot courses have progressed, the students have been taught English by the teacher and the teacher has been taught chemistry by the students, in English.

The third paper is expected to contain qualitative research as to the student perception of the courses provided in line with McGinity (1993) as education is a social not natural phenomenon and takes into account perspective, intention and context.

Students are predominantly female (approx. 80%) probably as a direct consequence of action taken more than 25 years ago to entice girls at secondary school in Thailand to choose science (Fensham 1986). Before this, boys had continually outperformed girls with the exception of a study conducted by Klainin (1984).

Whilst English for Specific Purposes (ESP) suggests that it would be prudent to master the general symbols, sounds and grammar of English first (Orr 2001), it is not possible in this case due to the nature of the Thai education system and its history of teacher centred rote learning that has stifled the creativity of Thai students over the years. This makes the goal of students being autonomous readers in their field according to innovations like the REST Project (Hudson 1991) impossible at this time; however, the introduction of student centred learning in accordance with Thailand’s Education Act of 1999, will hopefully resolve this problem in the future if it is implemented correctly and in a timely manner.

In addition, the use of the communicative approach has been widely adopted throughout the world; however, it needs to be used sparingly with a more eclectic attitude towards teaching as indicated by a reflective study by Kajornboon (2000). Ellis (1996) warns that the communicative approach is not for everyone and that, “an integration of Eastern and Western teaching practices can be jointly explored.”

BACKGROUND TO ESP AND THIS STUDY

There are many commentators in the industry who have produced books and papers that explain the background of ESP. Gatehouse (2001) details absolute and variable characteristics of ESP whilst giving an overview of the views of
Hutchinson and Waters (1987), highlighting the ESP tree. Richards (2001) gives a brief history of ESP and cites Strevens (1977) as well as Richterich and Chanceril (1978) whilst explaining the importance of the needs analysis in ESP. Graves was an inspiration for the initial writing course as her Framework of Course Development Processes (Graves 1996a) was used extensively in conjunction with the Systems Approach to Training (Graham 2007) and Johnson’s Process of Course Development for the Teacher (Graves 1996b). No study would be complete without mention of task-based syllabus design and Long and Crookes (1992); however, it is important that whilst research into prudent practices and pedagogy is paramount in the planning stages, as the piloting of courses have proved, an eclectic approach is needed to galvanise the project to ensure success.

As mentioned previously, Thailand’s Education Act of 1999 instructed the education fraternity to adopt a “learner-centred” approach to teaching, moving away from the less communicative “teacher-centred” approach. In preparation for the courses provided, the outline of, “A Learning Centred Approach to ESP” was adopted from Hutchinson and Waters (1987) as it had been previously used in other ESP contexts and had proved successful. In addition, a course developed with communicative goals and goals becoming objectives as detailed by Dubin and Olshtain (1986) was implemented as this too has been recognised by academics as sound practice. It is interesting to note that whilst these books are twenty years old, they still hold up to scrutiny today and at the time of writing this paper, have not been revised.

Countries such as Ukraine have conducted national ESP studies (Ministry of Education and Science 2003) and produced an ESP National Curriculum for Universities in conjunction with the British Council (Ministry of Education and Science 2005) to prepare for European integration, something that other countries may wish to consider.

ESP has countless components and combinations that evolve over time to fulfil the needs within a wide range of social, academic and work related contexts (Orr 2001). Orr (2002) states that ESP has three specific referents in the world of English language education in that:

1. It has specific subsets of the English language that are required to carry out specific tasks for specific purposes.
2. It is a branch of language education that studies and teaches subsets of English to assist learners in successfully carrying out specific tasks for specific purposes.
3. It is a movement that has popularised the ESP profession and its work with ESP discourse.

Johns and Dudley-Evans (1991) emphasise the careful research and design of pedagogical materials and activities within a specific learning context concentrating on needs assessment and discourse analysis of the students concerned. ESP in this context is truly international in scope and can be exemplified by the job opportunities offered to past students from this faculty.

THE MOVE FROM ONE TO FOUR SKILLS

Richards (2001) states the development of syllabus design can be organised into skill based, functional and task based syllabuses and like Herunramdej and Chinokul (2006) an integrated syllabus was considered the best option as an eclectic approach to language teaching will use the best possible methods to ensure the maximum results.

Due to the time constraints of a course that is three hours a week for sixteen weeks (48 hours in total), not all sub-skills of the four skills can be covered to an acceptable degree so the use of research in the classroom and in the field was used to decide what sub-skills would be paramount. There are barriers to effective learning in the classroom (Finch 2002) which need to be addressed so that effective learning takes place. Some students have been labelled failures in the past where English is concerned and need to be motivated to succeed.

An activity based genre approach to teaching writing to students with learning disabilities was an approach considered for adoption as it was compared to teaching low proficiency students in a study by Firkins et al. (2007) and proved useful when deconstructing texts and then reconstructing them in class. A study by Chinnawongs (2002) confirms the Language Center’s belief that combining the product and process approaches to writing gives the students the best opportunity to generate and organise their own ideas. Feedback for writing tasks has continued on an individual basis in both written and oral forms.

The SWELL method (Teo 2007) has confirmed that the group work strategy in planning and editing students writing has a sound base for success and is by far the strongest component of the course at this time.

An essay style assignment focussing on language, organisation and content in line with accepted humanities tertiary education practise (Watson Todd et al. 2007) had been successfully completed by the pilot writing course students and
was the basis of the new integrated course (Blanchard and Root 2003), as this would lead into the presentation and speaking phase later. A very simple experiment was chosen as the topic as this would give the students the opportunity to explain the experiments they had completed in their previous chemistry coursework, giving them the context they needed to succeed. A model was given to the students for the presentation and then the process was explained of how to attain that final product.

It was important to find a middle ground between over correcting and under correcting students’ work (Green 1998) as it was important to help the students grow and to keep improving. Cowie (2001) states that writing feedback has three main benefits:

1. It validates student work and effort by showing that their teacher cares about and is interested in their writing.
2. It helps a few students rewrite their past work by giving text-specific advice.
3. It can motivate other students for their next piece of work.

This feedback is useful for all skills, not just for writing and over the duration of the pilot courses, it has proven very effective in motivating the students to produce their best work. There seems to be substantial published research on the feedback of writing, possibly more than the other three skills; however, there are many areas of similarity that can be deemed from studies by Pathak and Keng (2001), Chinnawongs (2001) Nassaji (2007) and Padgate (2001) relevant to the students in our classrooms.

The presentation that students have to complete at least twice, so as to see their improvement and provide further motivation due to their success (Yule 1996), is to help with the perceived embarrassment of losing face by making mistakes, something that even professional Thais admit to (May 2007). Students were further encouraged by allowing them to grade their peers, which worked extremely well (Milanic 2007).

Students need confidence in speaking and this can be done by having a class-centred classroom (Senior 2006) by helping students to achieve a positive attitude to themselves and others in the class and creating a positive atmosphere which will motivate the students to achieve (Songsiri 2007).

With regard to reading skills, some would argue that it is the most important skill in ESP due to its primary importance in many EFL environments (Johns and Dudley-Evans 1991), so real training in skimming and scanning was considered vital for the study purposes of the students, which in effect, gives them their context for studying reading in the classroom. Metacognitive strategy training will give meaning to their reading transforming a student’s declarative knowledge of reading strategies into procedural knowledge (Dhieb-Henia 2006). Soranastaporn (2002) confirms this with a study highlighting skimming, scanning, the use of background knowledge and guessing meaning from context. Planning, monitoring and checking the learning process are needed in addition to normal reading sub-skills and were implemented into the pilot courses.

Research into learning strategies of high and low language learning achievers (Lerdpaisalwong and Gajaseni 2006) gives insight as to ways to bring out the best in our students. If we understand their learning strategies and help them with their quest for knowledge, they will be motivated to use the materials provided and take control and responsibility for their own learning.

**TRIALLING OF MATERIALS**

The materials used were as authentic as possible (Hudson 1991) and whilst it was not possible to have everything tailor made (Orr 2001), every effort was made to show the context of the tasks to be completed and how it related to the students themselves. Baumgardner and Kennedy (1991) demonstrated the use of materials in a local context and this was achieved by looking at the experiments that have already been conducted by the students in their chemistry classes. This in conjunction with problem solving activities (Souillard and Kerr 1990) had a positive effect when trialled in the pilot courses.

The reading of research articles would be considered by most academics as one of the most important aspects of a course such as this; however, the level of English of the articles has proved too advanced and so materials from other sources were used as they were of a more suitable level for the students. Placement test scores over a period of nearly five years have shown students to be either false beginners or at best elementary level learners, so materials had to be at a level that would be both challenging and attainable.

This is not a criticism of the students who have repeatedly served as examples of responsibility and diligence; it is more a criticism of a system that allows students to progress for ten years in their English language studies without
effectively evaluating the specific concerns of students, parents, teachers, schools and local/national business. A programme based review of English language education would reinforce the strengths and overcome the weaknesses, thus satisfying the “powers that be (Mackay 1994).”

Basic Reading Power (Mikulecky and Jeffries 1997) contained enough material for initial skimming and scanning, as well as understanding and building sentences and paragraphs. In addition, more specific science based materials were taken from Cause & Effect (Ackert 1999a), Facts & Figures (Ackert 1999b) and Thoughts & Notions (Lee and Bushby 2000), with a view to using the test booklets for assessment purposes.

The lessons followed guidelines emphasised by Professor Carol McGuinness (Nimkannon 2007), consisting of four elements:

1. Learning objectives.
2. Thinking activities.
3. Reflection or evaluation.
4. Making connections of what they have just learned.

The materials were chosen with a view to students being encouraged to ask questions. This is a problem for many Thai students; however, the students in this study, by the nature of them being science students, are willing to experiment with new ideas and the concept of asking questions proved to be easy for them to assimilate. This is in stark contrast to other majors at the university where the asking of questions is still considered a foreign concept. Providing a model or framework in context (Abbott 1980) encouraged the learners to ask questions out of curiosity rather than for compliance to a teachers’ request.

The idea to try materials that advertise, “thinking skills” proved popular with the students as they had to solve problems, make decisions and search for meaning by comparing and contrasting in addition to finding similarities and differences in line with views expressed by Professor Carol McGuinness (Nimkannon 2007). She explains that students can be provoked to think by using vocabulary like solve, sort it out, estimate, make a plan etc. ideal for scientific thinking. Basic Reading Power (Mikulecky and Jeffries 1997) contained thinking exercises and although some academics may consider it inappropriate to force students to think in their L2, pilot courses proved that students were more than happy to experiment with the questions asked as long as there was not a penalty for an incorrect answer.

Listening materials were initially a problem; however, after experimentation during the pilot courses, it was decided to use listen texts from the reading books on subjects related to what the students had completed previously. Reading comprehension questions to practice skimming, scanning and context were used for listening purposes. This involved the students having to practice using the same listening and reading text to scaffold at the beginning and then when the students became more confident, they were weaned off the reading text to use just the listening text.

There was a grammar element to the course which consisted of exercises from Recycling Elementary English (West 2002) and this consisted of exercises to combat problems in writing highlighted in a study by Lush (2002), which also had external validity when dealing with general English language errors. A small research project conducted on two Bachelor of Education classes with English majors confirmed that the areas indicated in Lush’s research were relevant to the students at Udon Thani Rajabhat University.

Finally, there was further development of science based materials using Basic English for Science (Donovan 1978) which is a specific book to teach English for science. There was not enough time in the course to complete many tasks from this book; however, during the pilot courses for the initial writing course, many exercises were completed successfully, though the students did find the exercises difficult.

DISCUSSION

At present, this course is taught by a native speaker of English; however, it is the intention of the Language Center that all courses should be taught by Thai teachers of English to expose the teachers to different teaching strategies making them more fulfilled and confident in what they do. Culture is not a barrier (Sowden 2007) and whilst the debate continues over the merits of native speaker versus non-native speaker, it is the authors opinion that a Thai teacher of English has many aspects to their teaching which gives them empathy with the students concerning the problems in learning the English language, after all, they were themselves once in a similar situation in having to learn the same foreign language.
This coupled with the ability to speak in Thai to overcome problems in the classroom gives Thai teachers an advantage as long as they feel confident in what they are doing. An element of scaffolding is necessary until the teacher concerned feels that they can complete the teaching on their own. Teachers can expand their roles in the classroom to be that of cognitive and effective physician (Finch 2002) diagnosing and healing learning and social ailments whilst using their knowledge of Second Language Acquisition (SLA) to take into account neurological, cognitive, affective and linguistic factors in conjunction with their own theories (de Kleine 2007).

It was Block (2003) cited by Dowling (2005) that described Gass’s model of SLA process:

1. Apperceived input.
2. Comprehended input.
3. Intake.
4. Integrate.
5. Output.

The output is not just the end product; it is fed back into the system as part of the process again. Reflective practice by Thai teachers of English of how they learned the English language and also the way their students learn will be beneficial to all concerned.

Dobson (2006) explains that teachers are expected to have proficiency in teaching which involves having or knowing how to get teaching-learning activities and that these activities should be controlled by the course objectives rather than the other way round.

Assessment was conducted to show student mastery of that which was actually taught (Orr 2001). Assessment has to be “generally specific” in nature and although not intended to test subject knowledge or text content knowledge, was from a familiar area (Alderson 1988). Assessment was therefore a written experiment, a presentation of an experiment, demonstration of reading and listening skills (skimming, scanning and context) using tests from the course books used on the course. Listening was slightly different as listening texts were taken from the books and reading comprehension questions used. This proved a very effective way to test the listening skills and keep the subject matter relevant.

The latest trend seems to be a Constructivism approach to teaching, expounded at many conferences over the last year. More research is needed to confirm how important student-teacher interaction is in regard to science and the teaching of English.

The Faculty of Science has now requested training for the Bachelor of Education programme, so there is now the need to produce a course for science teachers which opens up opportunities to have students explaining in English how to conduct experiments as if they were teaching in a classroom. The use of simple experiments like, “Rock and Roll Crystals” made by John Adams Trading Co. Ltd. are now being trialled with a view to being adopted in the new teachers’ course.

Kimball (1996) states, “Language instruction that foregrounds students’ needs points to meaningful practice and meaning making skills for learners to assume responsibility for their own discovery and fulfilment.” The needs of the students as well as the faculty need to be satisfied for courses to succeed as in the business world that has enveloped education, the question that is always asked is, “Who is the final customer?” Tubtimtong (1996) informs us that the needs analysis continues to play a pivotal role in providing insights into language learning as objectives and goals of stakeholders vary with changing socio-economic conditions.

For a paper such as this to have any impact on the classroom, the teachers involved in delivering the courses need to be convinced with the findings which resonate with their professional experience and can translate them into practical activities and strategies for classroom use, to be widely disseminated through respected professional networks (Ratcliffe et al. 2004). Students need to be encouraged to be active, co-operative and autonomous learners (Rogers and Mulyana 1996) in order to continue their journey of lifelong learning.
REFERENCES

PRIMARY SCIENCE CURRICULUM, THE CONSTRAINTS AND LIMITATIONS OF LEARNING AND TEACHING AN ‘OVER-STUFFED’ SCIENCE CURRICULUM: A CASE STUDY FROM FIJI

Willi Suluma
The University of the South Pacific
Fiji

ABSTRACT

The content of this paper reflects on my experience of learning and teaching science in Fiji. The critical autoethnography approach employed to generate data for this study places emphasis on my educational journey, where I have used multiple genres, such as dialogue [with teachers and students] and short stories, to represent and interrogate my lived experiences. The study considered my lived experiences as a student, a teacher and a teacher educator, and set out to generate findings pertinent to the following questions: 1. Is the Fiji Primary Science curriculum ‘overstuffed’? If so, in what nature and to what extent? 2. What are the constraints and limitations faced by teachers in effectively teaching science in Fiji? 3. What are the constraints and limitations faced by Fijian students in constructively learning science? 4. Can an ‘overstuffed curriculum’ be responsible for students’ poor performances and negative perceptions of science in Fiji? Findings generated from this study emphasise that the present primary science curriculum in Fiji is viewed by teachers and students involved in this study as overcrowded with a lot of factual content. Furthermore, the study highlighted that poor achievement and the negative perception of science by students in Fiji can be attributed to factors ranging from the science curriculum to teaching pedagogies generally employed in Fiji. The paper also unearthed teaching and learning constraints encountered by teachers (and students) when attempting to teach (and learn) science in a constructive manner. Finally recommendations on teaching approaches that underpin constructivism in science to promote conceptual understanding are also discussed.

BACKGROUND

Curricula are overcrowded with factual content and still rigidly prescribed for all schools across all levels. For teachers, coverage of the curriculum detail becomes their key task, rather than the development of conceptual understanding using methods of enquiry and problem solving.

(Fiji Island Education Commission, 2000, p. 78)

The above findings of the Fiji Education Commission in 2000 highlighted not only the breadth of curriculum content across all levels in Fiji but its impact on teachers and students in the classroom. In expanding on this impact, the Commission commented that, “There seems to be no doubt that rote-learning is over emphasised in many subjects offered at all level in Fiji” (p. 269). In this context the curriculum is viewed as a ‘content, subject matter’ syllabus.

As a student brought up in a learning environment where passive learning was emphasised due to the coverage of a crowded syllabus, I experienced difficulty in grasping and understanding scientific concepts and processes during science lessons. In most cases during science lessons we (the students) were merely spoon-fed with information without having to investigate, experiment or discover. As I continued through school, I discovered that learning had become a non-challenging and boring encounter in which classes were teacher-centred. Further more, I gathered that knowledge gained from such mode of learning held very little meaning and in some instances I found the information very difficult to relate to.

Furthermore, becoming a teacher and having to teach the same science curriculum at Primary school, I experienced first hand the difficulty and pressure mounted on teachers by higher authorities that forces them to teach passively. In addition, I also witnessed the extensive breadth of curriculum content in primary schools that teachers were and are required to cover in a school year as part of their key responsibilities. Moreover, the limited learning-time allocated for each subject does not allow for a thorough coverage of such a crowded content curriculum. I also gathered that the high expectations of stakeholders in the school, including parents, compounded the situation leaving teachers helpless with no other alternative but to teach passively in order to cover the syllabus and force learning through rote methods and cramming.
In light of the above reflection and experience, the study assessed and analysed the science curriculum content of a school in Fiji and critically enquired into the limitations and constraints encountered by both teachers and students in constructively teaching and learning science.

PURPOSE OF THE RESEARCH

The study aims to enquire and explore the following questions:

- Is the Fiji Primary Science curriculum ‘overstuffed’? In what nature and to what extent?
- What are the constraints and limitations faced by teachers in effectively teaching science?
- What are the constraints and limitations faced by students in learning and understanding science?
- Can an ‘overstuffed curriculum’ be a cause of students’ poor performances and students’ negative perceptions of science in Fiji?

SIGNIFICANCE OF THE STUDY

The poor achievement and the negative perception of science by students in Fiji could be attributed to factors ranging from curriculum to teaching and learning approaches. The outcome of this study, therefore, will shed light on how the science curriculum, to some extent, can be responsible for the poor performances and negative perceptions of science that exist amongst students.

Further more, findings of this study will unearth science curriculum and teaching and learning issues that would provide valuable information to teachers, curriculum developers and policy makers. These stakeholders may use these findings to illuminate and guide them towards the development and implementation of a more teacher- and student-friendly science curriculum that promotes constructive teaching and conceptual learning.

Most importantly, findings from this study will be significant to my present and future professional praxis as I explore my own situation in relation to others [i.e. students, teachers and my cultural context].

STUDY CONTEXT

Curriculum history

Fiji was a crown colony of Britain since 1874 until it achieved independence in 1970. Traditional education, where the emphasis was on continuity and maintenance of community and culture, existed in Fiji before the introduction of formal education by Christian missionaries in the early 19th century. This was the beginning of formal education in Fiji. Their curriculum was primarily concerned with transforming society basing it on Christian principles. In such a system of education, the community did not participate in curriculum development. The emphasis was on the emergence of an academic focus in schooling whereby the ‘centre-periphery model’ of curriculum development was adopted. This located power firmly within the grasp of those who took curriculum decisions.

The 1969 Fiji Education Commission examined the colonial system of education and argued that much of what was being taught was irrelevant to the local needs and aspirations. Despite concerns raised by the Commission many elements of the earlier curriculum still remain. The most significant curriculum reform in Fiji occurred in May, 1970 and was initiated by the United Nations Development Program (UNDP) in conjunction with the United Nations Educational, Scientific, Cultural Organisation (UNESCO). The primary aim was to prepare a comprehensive and relevant curriculum for Fiji. The project also assisted in the development of teaching aids, school texts and the training of teachers to ensure effective implementation. To date, the same curriculum is still used in Fijian schools with very little review and reform carried out.

Curriculum in Fiji today

According to the Fiji Island Education Commission, (2000, p. 278):

Despite curriculum reforms in the last three decades, the school curriculum in Fiji has remained largely examination driven and prescriptive in nature. There is a mismatch between what the teachers say or what the prescribed handbook suggest, and what teachers actually do in the classroom. There is very little teacher participation in the curriculum development process. The curriculum is subject based, developed and disseminated on a centre-peripheral model. The
curriculum materials prepared by the Curriculum Development Unit are expected to be teacher proof.

The above scenario depicts the current status of curricula in Fiji. It highlights the lack of involvement of teachers in the decision-making and formulation of the curriculum resulting, in the development of an overcrowded and undernourished curriculum that is exam-driven. Further more, such curricula are bound to give rise to teaching and learning issues, as highlighted the report of the Fiji Island Education Commission, 2000. The implication is that such curricula will have a negative impact on both teachers, as implementers of the curriculum, and students, as the recipients.

RESEARCH METHODS

The research methods adopted in this study are aligned to the ontological and epistemological beliefs of the writer and they frame the paradigms of this study. Furthermore, triangulation was employed which according to Mathison (1988) is “good research practice” that “obligates the researcher…to use multiple methods, data sources…to enhance the validity of research findings.” (p. 13). Mathison also argued that it is necessary to use multiple methods and data sources in the execution of a study in order to withstand critique by colleagues.

According to Imenda and Muyangwa (2000) the selected design should be appropriate to the problem being investigated. In some cases there is a need to employ a combination of research approaches in order to satisfactorily address a particular research problem. This qualitative study embracing two paradigms, critical autoethnography and evaluation research was adopted to collect and generate data.

The critical autoethnography approach was employed due to its appropriateness, not only to the research paradigm, but to the ontological beliefs in which this proposed enquiry is grounded on. According to Spry (2001) autoethnography is the connection between the autobiographic impulses and ethnographic moments, and it can be depicted as “self-narratives that critique the situation of self with others in the social contexts” (p. 710).

Furthermore, evaluation research was also employed due to the need to evaluate the curriculum under investigation. Cohen and Manion (1994) emphasised that evaluation research involves a systematic collection of information on the worth of programmes, products or techniques and then using that information to make value judgements concerning the worth of the programmes, products and techniques.

Research population

Some students and teachers in a local school were identified and invited to become participants of this study. However, due to the critical and constructivist theoretical framework of the study representative sampling was not necessary since population cannot be viewed as a fixed entity.

Generation of data

A number of different types of research instruments were employed to collect the data. With the notion of writing-as-enquiry (Richardson & St. Pierre, 2005) data was generated through two sources.

- The history of my lived experiences as a student, science teacher and a teacher educator.
- My role as a researcher.

Furthermore, since the study also adopted an evaluation approach where the focus lay in the identification, collection and analysis of the curriculum content. In this process my own past and current experience and observation was employed to unpack the notion of an ‘overstuffed’ science curriculum. In this way, the critical auto/ethnography enquiry allowed for reflection and revisitation of lived experiences. Further more field observation, questionnaires and informal interviews were employed to generate rich first-hand data from participants. As Silverman (1993) noted, observation, interviews, recording and transcribing are the four major methods of collecting qualitative data.

Presentation of data

Two types of data were: collected, generated and presented. Stories of participants during informal interview constitute the major source of the presented data. Secondly, critical self-reflection on my lived experiences as a student, a teacher and a teacher educator generated findings that are important to this study. According to Afonso (2002) cited in Willis (2007) the three types of reflection are contextual reflection, dispositional reflection and
experimental reflection. Findings generated from these three types of reflection will be used to critique my experiences of situation in the educative contexts considered for this study. Furthermore, data generated from the field through observation, informal interview and discussions were transformed into short stories and written narratives that will draw the reader into subject’s reality and promote dialogue between author and the reader(s). To bring out emotions and concerns, actual spoken words of participants are presented in short vignettes.

**FINDINGS: INTERPRETATION AND REFLECTION**

Finding generated from this study are interpreted and discussed under the following categories:

- Status of the Science curriculum
- Constraints and Limitations in Teaching Science
- Constraints and Limitations in Learning Science

**Status of the Science Curriculum**

My experiences as a student, a teacher, and a teacher educator continuously highlight the hardship encountered in learning and teaching science with such a full curriculum. This was also noted by the students and teachers who participated in this study. For example, on student made the following comment:

**Mrs Luisa** there are 30 general topics, 10 topics each term, in each of the 30 units you will have two to three subtopics in the form of lessons to teach. Overall you will be looking at an average of 70 - 80 subtopics to teach in a school year.

This alone indicated the breadth of content in the primary science curriculum in Fiji. This statement was reinforced by Jone when he stated that, “It is very seldom that we are able to complete all science activities on time.” A second student, Praneel added that, “I notice that we’re only rushing through each unit so that we can move on and sometimes I get confused...”

These comments suggest that students themselves were very aware of the vast amount of work to be covered in science every year. Furthermore, some, in their stories, told of teachers using up times allocated for other non-academic subjects like music, physical education and art for science lessons and activities.

Moreover, teachers commented that the current content of the primary science curriculum in Fiji was ‘a mile wide and an inch deep’. Mr Kumar placed this feeling in the following words.

**Mr Kumar:** In most classes including my class, we have about thirty broad topics that lacked depth to cover in an academic year. In these thirty units there are at least two or three subtopics in the form of lessons in them to be taught.

The breadth of the current primary science curriculum in Fiji has contributed to the ineffectiveness of the teaching of the subject in the classroom. This was reiterated by most of the teachers. For example, Mrs Kara sums it up this way.

**Mrs Kara:** With the current situation that I am in, I have discouraged students from going out to do activities that can be easily taught in the classroom in a rather short period of time. I have been doing this in our science lessons due to time limitation. I know that students are being neglected from self-learning through discovering but I cannot help it. I have an exam class and the emphasis is on passing exams.

Overall, the comments made by both teachers and student-teachers reinforced the negative impact of an overstuffed science curriculum on teachers to teach effectively in the classroom.

**Constraints and limitations in teaching science**

The difficulties I encountered as a science teacher were reiterated by other teachers during our discussions. The various constraints and limitation faced by teachers when teaching an overstuffed curriculum ranged from teaching difficulties to student learning problems. This was highlighted by Mr Kumar when he made the following statement.

**Mr Kumar:** There are a lot of difficulties that I encounter in teaching science. Firstly, the task of covering all topics prescribed for the year in a very limited time allocation. Secondly, the objective to teach science in a student centred approach where students are encouraged to be the centre of
learning. This is always difficult, since time is not always insufficient. Further to this is my inability to allow student to be engaged in worthwhile learning activities such as field trips, excursions, experiments, group research, group work etc.

The other issue highlighted by teachers were their inability to teach science the way they wanted, that is to allow for more hands-on and group-work activities that will generate learning. Mrs Kara explained the issue in the following words.

Mrs Kara  The difficulty that I often face when teaching science is making an effort to ensure that students are allowed to engage in all learning activities that they should be doing, to promote and enhance learning with understanding. To be honest, this is not happening in my class.

Furthermore, the breadth of the content with limited time allocated to teach it forces teachers to employ passive learning approaches. As Mrs Litia stated, “I also encounter teaching difficulties, with this I mean not being able to teach science thoroughly and as effectively as I can. To be honest, I teach science to prepare students to passing exams.”

Inability to satisfactorily complete science content prescribed for a year was another issue that was generally reiterated by teachers. To some teachers like Mrs Litia, it was impossible to complete the syllabus and at the same time be able to teach it thoroughly [effectively]. She said, “I have been teaching science at primary level now for some years and I can confirm that I have not been able to completely cover my syllabus in any year.” In my own reflection as a teacher, I would agree with Mrs Litia because it does not just work out if one considers the number of lessons against the time allocated in an academic year.

The statements above indicate that the curriculum imposes certain difficulties upon the teachers. It has a high content load with a limited time-allocation for topics and appears to be exam-driven. This means that in order to cover the syllabus and maintain good pass percentages teachers are forced to teach about science and not teach scientific thinking. As a result teachers tend to employ teaching strategies that encourage passive learning.

**Constraints and limitations in learning science**

My experience, as a student, in learning science with such a full curriculum meant that there were times when I actually disliked the subject. This was also reflected by the experience of some of the students who participated in this study. It was common in stories shared by students that they were finding science a difficult subject to learn. This was due to reasons like, the boring teaching approach, lack of preparation from teachers and the medium of instruction.

For example, most students commented that the approach teachers used in the classroom failed to generate real learning. As Joeli stated, “I find it hard to learn science, when teachers just explain from the front. Sometimes when they use difficult words, I cannot get what they are trying to explain.” The literature indicates that students encounter difficulty in understanding when knowledge is merely transferred from teachers (Woolfolk, 1993).

Other relating issues arising from students’ stories and experiences include: difficulty in understanding the medium of instruction, boredom caused by passive teaching approaches, lack of time for individual assistance, and a lack of reflection-time due to a teaching practice of rushing through topics. It was also gathered that the learning difficulties encountered by students could be attributed to the poor nature of the science curriculum [overstuffed with content and undernourished because of a lack of time for investigative experience] forcing teachers to ineffective teaching pedagogies. This has contributed to student poor performance in the subject. In some instances it has lead students to dislike the subject.

**RECOMMENDATIONS AND IMPLICATIONS**

The difficulties encountered by both teachers and students in the teaching and learning of science are multifaceted, and can be attributed, in part, to the current over-crowded nature of the science curriculum in Fiji. Many of the common difficulties faced by the participants of this study (teachers and students) can be linked to teaching and learning approaches in the classroom that stem the need to rush the of the many required topics. While teachers are not able to teach constructively, as many would like to, students are frustrated because they are forced to learn without understanding.

According to Fratt (2002), an overstuffed curriculum is, by nature, undernourished. It lacks the quality of content and teaching method that would promote and enhance conceptual learning. It is therefore mandatory, for curriculum developers, teachers, policy makers and other stakeholders to ensure that the curriculum is well nourished. In Fiji, there is a need for a systematic re-examination of the total science curriculum including the
science syllabi, the culture of teaching and learning science in schools, the nature of students and the needs of the broader community.

It is important to note that learning is not necessarily an outcome of teaching. Cognitive research reveals that even with what is taken to be good instruction, many students, including academically talented ones, understand less than teachers think they do. With determination, students taking an examination are commonly able to identify what they have been told or what they have read. However, careful probing often shows that their understanding is limited or distorted, if not altogether wrong. Schools should be allowed pick the most important concepts and concentrate upon the development of skills and quality understanding in these areas rather than rushing through a huge quantity of information.

The way students learning and understand is influenced by the nature of their existing ideas. Students construct their own meanings regardless of how clearly teachers or books tell them things. Mostly, students do this by connecting new information and concepts to what they already believe. According to Brooks and Brooks (1993), concepts are learned best when they are encountered in a variety of contexts and expressed in a variety of ways, for that ensures that there are more opportunities for these new ideas to become imbedded in the students’ individual knowledge systems.

Furthermore, psychologists have shown that students learn more effectively when information is initially presented in tangible, concrete ways that are directly accessible to their senses – either visual, auditory, or tactile. Abstract ideas will grow as students use concrete experiences to create the context of some relevant conceptual structure and develop from this their more generalised ideas. The difficulties many students have in grasping abstractions are often masked by their ability to remember and recite technical terms that they do not understand. As a result, teachers - from primary through secondary school - sometimes overestimate the ability of their students to handle abstractions, and they take the students' use of the right words as evidence of understanding.

In order to promote a constructivist friendly atmosphere that promotes constructive teaching and learning in the classroom, teachers might consider and explore the following: begin lessons with questions about nature, engage students actively in the learning process, emphasize the collection and categorisation of evidence, organise cooperative group-work and place less emphasis on the memorization of technical vocabulary. Conceptual understanding rather than vocabulary should be the main purpose of science teaching.

Furthermore, constructivism in teaching and learning should, to some extent, reflect scientific values. Science is more than a body of knowledge. It is away of knowing that is at its heart, a social activity that incorporates certain human values. Curiosity, creativity, imagination and honesty are all characteristics of scientific endeavour. In learning science, students should be encouraged to develop such values as part of their experience. Therefore a science classroom should arouse and welcome curiosity, creativity, a spirit of healthy questioning and eagerness to learn.

Science teaching should possibly extend beyond the school. Children learn from their parents, siblings, other relatives, peers, and adult authority figures, as well as from teachers. They learn from movies, television, radio, records, trade books and magazines, and home computers, and from going to museums and zoos, parties, club meetings, rock concerts, and sports events, as well as from schoolbooks and the school environment in general. Science teachers should exploit the rich resources of the larger community and involve parents and other concerned adults in useful ways.

Constructivist learning takes time. Students need to be allowed to explore, make observations, make mistakes, repeat observations, collect things and finally to create and test new ideas. It also important to allow students to take time to deal with questions at hand, time for asking around, reading, and arguing; time to wrestle with unfamiliar and counterintuitive ideas and for coming to see the advantage of thinking in a different way. Moreover, any topic in science that is taught only in a single lesson is unlikely to leave a durable trace by the end of schooling. To take hold and mature, concepts must not just be presented to students from time to time but must be offered to them periodically in different contexts and at increasing levels of sophistication (Von Glasersfeld, 1995).

REFERENCES


A STUDY OF A NATION-WIDE PILOT PROGRAM IN SCHOOL MATHEMATICS

Kevin Swincicky
North Albany Senior High School
Australia

John Malone
Curtin University of Technology
Australia

ABSTRACT

A senior high school in Western Australia participated in the piloting of the National Mathematics Program initiative organised by the International Centre for Excellence. The opportunity to modify the school’s Year 8 program and to implement change in the schools feeder primary schools occurred with the second stage of the pilot program’s Transition Phase 1 and 2, implemented in 2007. This paper presents an overview of the research methodology and presents some of the findings.

INTRODUCTION

There is a change happening in many western civilisations in the way that we view the importance of mathematics in world leadership. The TIMSS (Third International Mathematics and Science Study 1995) and its successors (1999 and 2003) placed the United States, Australia and New Zealand well behind countries such as Singapore, Chinese Taipei and Japan. Business leaders in the United States expressed concern with … increasing foreign competition especially from Asian nations and the decreasing interest in Science, Technology, Engineering and Mathematics among American students … (Walters, 2005, p. 1) to prompt campaigns with the goal to double the number of graduates with bachelor’s degrees by the year 2015.

In addition to Australia’s position in International Benchmarks, the lack of consistency in curriculum outcomes across Australia was also being questioned. The Curriculum Corporation in its consultation draft National Consistency in Curriculum Outcomes (NCCO) and under the Schools Assistance Act (2004) required the States and Territories in Australia to implement changes in their curriculum according to the Statements of Learning either as part of their next curriculum review, if that occurred between 2006 and 2008, or before 1st January 2008. Equally important was the requirement that all States and Territories implement common testing standards, including a common national test by 1st January 2008.

The International Centre of Excellence for Education in Mathematics (ICE–EM) was commissioned to write a program for lower secondary students and primary students with appropriate textbooks and then administer the program Australia wide. After the first year (2006) in this pilot program, the first author realised that for this initiative to be successful the need for consistency with curriculum among our feeder primary schools was necessary particularly in the Outcome Number where mathematics staff at the high school had expressed over many years concerns about students’ lack of skills and understanding in Number.

AIMS OF THE STUDY

The research reported in this paper addresses the content and activities in the pilot program textbooks – that is, whether a teacher would need to change his/her pedagogy when using the textbooks and whether the content has been levelled in sequential and appropriate stages for students and staff at one high school and three of its feeder primary schools in Western Australia – and whether there is an improvement in standards from adopting the new course of study.

RESEARCH METHODS

The research was conducted in three primary schools and one senior high school in a large country setting in Western Australia involving over 300 students and 10 teachers. Two of the primary schools are major feeder schools for the high school and the third fluctuates from year to year. Classes are of mixed ability in all the participating schools, and in the primary schools, students in Year 6 and 7 are mixed together in two of the schools and Year 7 in the third school. Three high school classes implemented the Year 7 program for their Year 8 students. This decision was made based on the
teachers’ knowledge of past students’ understanding of major concepts in Number. Calculators were not used in the schools implementing the program fully with an emphasis placed on teachers developing students’ mental computational strategies.

This study employed qualitative and quantitative paradigms (mixed method research (Johnson & Onwuegbuzie, 2004) or fourth generation evaluation (Guba & Lincoln, 1989)) to investigate data. Western Australian Literacy and Numeracy Assessment (WALNA) data had been distributed to schools since 2003 and this data was used to make comparisons between students or groups employing non-experimental (Johnson, 2001) techniques over the course of this study. This was combined with observations of, and discussions with, students, the Numeracy Coordinator and teachers in order to conduct cross case comparisons and analysis in a natural setting. The study utilised student and teacher questionnaires and compared content between the textbook authors and the K–10 Syllabus manuals in Western Australia and then examined how both of these aspects related to the Statements of Learning for Mathematics (SLM) developed by the Curriculum Corporation (2006).

**Questionnaires**

The student questionnaire developed by Australian Council for Educational Research (ACER) (Ingvarson et al, 2004) was administered at the beginning of the study and again after six months when students were told to consider their mathematics education over the first half of this year. The aim was to map any changes in student attitudes to mathematics and learning between the student’s previous learning experiences and the learning that took place in the first semester when the pilot program was implemented; either fully, partially or not at all. Four extra questions were included in this posttest questionnaire where students were required to respond to the positives and negatives of the textbook and pilot program. The teacher questionnaire Teacher Belief and Attitude Survey was developed in part by this researcher, in part from work by Nisbet and Warren (2000) and in part by work from the Queensland Government research project Teachers Enhancing Numeracy (2005). The first author used this survey to get an overview of the teachers’ characteristics before the project was implemented. After six months, teachers were asked to respond to questions about the textbooks and pilot program.

**Western Australian Monitoring Standards in Education (WAMSE) scores**

Assessment tests for the WALNA program and the Department of Education and Training/University of Western Australia (DET/UWA) Year 8 testing program had been developed to reflect good classroom practice and written to cater for the diverse range of students in Western Australian schools. These tests provide students of all levels with an opportunity to perform to the maximum of their abilities. The development of the assessment materials ensures that there is no systematic bias associated with such factors as gender, culture or geographic location. Student WAMSE scores were used to investigate changes in student’s achievement and progress over two testing periods. For the primary school students this involved Years 5 and 7 and for the high school students between Years 7 and 8.

**RESULTS**

What changes in pedagogy are required by teachers in order to address the content in the new textbooks?

Teacher responses were generally positive about the content in the textbooks. Responses that were negative from teachers were concerned with the difficulty of the course for low achieving students and the difference between the Curriculum Framework Outcomes and the content in some chapters in the books.

The textbooks introduced many Number concepts through diagrams including the number line and this process assisted many students to understand operations. The number line became the favoured approach of all teachers in the development of students’ understanding of place value and equivalence of fractions and decimals. Through the textbook content, professional development for teachers was provided on developing the mental strategies outlined in the K–10 Syllabus document and the key points in the Statements for Learning in Number.

Mental strategies were not taught by teachers prior to this pilot program but by the end of the course, those teachers who formally taught the strategies felt positive about the benefits of introducing these skills. The mental strategies used in the textbooks and the problems with students’ understanding of basic facts the first author observed in this study are not new to mathematics learning (Baroody,
1984; Brumfield, & Moore, 1985; McCrae, 1985; Curriculum Framework, 1998; Grossman, 1985) but they may have been overlooked due to time constraints and the availability of calculators. What was evident, at the beginning of the study, was that the majority of students in Years 6, 7 and 8 did not have the skills nor had any formal instruction on how to calculate mentally. The first author believed this was a concern but found it difficult to convince some teachers of the benefits of introducing appropriate techniques to overcome these problems. The problem was highlighted at the high school were teachers, making a concerted effort to instruct students on mental strategies as outlined in Transition 2A, spent longer than expected and desired in the teaching of Number. Mental strategies are outlined in the Curriculum Framework, SLM and K–10 Syllabus as essential skills but the Aspect Use a calculator for all four operations became the dominant force in these classrooms. These observations had been reinforced in discussion with teachers at numerous meeting during 2006 and 2007. It should not be left to one year–group of teachers to introduce mental skills in the classroom. The process needs to start at home then through K–8 with each year building on the skills and reinforcing them in numerous situations and activities. There are many activities and strategies and professional journals Mathematics in School and Teaching Children Mathematics written to assist teachers wanting to learn more about ways to help student calculate mentally (Ball, 2007; Baroody, 2006; Becker et al., 2007; Morgan, 2000; Thompson, 1999; Yang, 2006).

In a high percentage of classes, students responded favourably to the interactive nature of the activities in the textbooks and in general, students were supportive of their peers and provided assistance when required. The notion that back to basics cannot be fun, was dispelled in the study with many students eager to participate in number games and improving their recall of basic multiplication facts through practice with the 10 x 10 multiplication table.

In many cases, the way the textbooks introduced topics or dealt with content was new to teachers, and on many occasions, teachers made favourable comments on the approach used by the textbook writers (Becker et al., 2007). The writers believed that there should be “a strong emphasis on understanding basic ideas and mastery of essential skills” (p.vi). This belief was shared by all teachers in this study with activities and worksheets design to ensure students work toward mastery of the 10 x 10 multiplication table. The books were written so that they did not require the use of a calculator, but mention was made that “some teachers may feel that it is appropriate for their students to undertake activities that involve calculator use”. AND “teachers should use it flexibly and supplement, where necessary, to meet local requirements and the needs of their students” (p.vi).

In six of the nine classrooms in this study, the calculator was not used in the teaching program, with teachers developing students’ mental strategies as outlined in the Transition textbooks, the Western Australian Curriculum Framework and the Statements of Learning for Mathematics. When calculators were used in classrooms, their use contributed to decreased mental recall and created misconceptions about order of operations.

This study highlighted the difficulty of implementing change in school classrooms, with teachers not always willing to explore modifications to their teaching and learning program nor to accept constructive advice from a colleague in regard to teacher misconceptions. This will be an issue for curriculum leaders in schools when the process of implementing a National curriculum commences in Australia. There are many changes that teachers must implement in their teaching programs but from my discussions with some teachers, this may not occur. The Curriculum Framework has provided teachers with the flexibility to implement any program in mathematics under the guise that the teacher is the best person to know what the student needs. While this notion is not being disputed, it is also creating problems. In discussion with one teacher, the comment was made that low achieving students would not have the intellectual capacity to do mental calculations, so the best that could be done for these students is to provide them with the opportunity to succeed with the calculator. If the first author could have taken this teacher into some of the primary school classes and let her observe the educational support students and students well below the Benchmark happily applying mental skills and succeeding, then it may have made her reflect on the comment she made.

The introduction of concepts in Number outlined in the textbooks were closely aligned to Getting it Right Numeracy (GIRN) and First Steps Mathematics strategies in Western Australia. This approach assisted some teachers with positive change in their pedagogy and provided effective professional development for teachers on GIRN principles. When used in classrooms it did impact positively on students’ understanding of concepts and this was reflected in the students’ WAMSE scores. GIRN professional development needs to be accessed by all teachers in primary and high school and its principles used by teachers. Currently there is a tendency for teachers to introduce algorithms without students understanding why a process works. Multiplication and division of fractions is a high level skill that most primary and high school teachers would not attempt, yet within one hour, two classes of Year 6 and 7 students had mastered the process without any algorithm being introduced. The process...
relies upon full class participation and discussion. The process would not be effective in classes where students sit passively completing worksheets.

Teachers felt that the first year had its problems but were keen to try it again next year. As one teacher stated:

_**For the first time in a long time there was a structure to a mathematics program. It’s not perfect as I would like to see more problem solving type activities but if you combine most of what is asked in the books with extra work it is great.**_

This response was similar to those expressed by the high school teachers with all three teachers eager to redo the program the following year adopting many of the approaches used to assist students understand and enjoy mathematics.

**Textbook content (intended curriculum) and its suitability for students?**

Students generally responded favourably to the course and textbook with more primary school students recording positive comments. Responses that were negative were from, low achieving students concerned with the difficulty of the course and high achieving students responding that the course and textbook was too easy and that they were not challenged by their teacher.

It was evident from the students’ comments that games were a contributing factor in students’ enjoyment of mathematics. These games were not computer based but simply hands on activities involving cards, counters and dice. They were used in the classroom to help students retain and improve their basic skills.

Games and group activities from the textbooks were used to reinforce Number concepts with great success in some classrooms with students making positive comments about their enjoyment of mathematics. When group work was not employed or students were not permitted to share their experiences as was evident in one classroom, students responded negatively about their learning and enjoyment of mathematics.

Students accepted the textbooks introduced into the classroom. A comment made by one teacher, that students found the textbooks boring, was not generally supported. Not all of his students found the textbooks boring; many felt comfortable with the textbook and saw it as step to higher mathematics. Other students responded that there was an opportunity to review the type examples and introduction when they did not understand the exercise. It is not possible to produce a textbook that would suit all learning styles and prior knowledge. It would be anticipated that some students would find the same sections easy while others would find the same sections difficult. This would also apply to worksheets. Many students in other classes made negative comments on the number of worksheets used in the classroom preferring to have a neat package provided by a textbook. The best that teachers can do is to provide opportunities and extension for all students by developing a learning program where students feel happy, engaged, inquisitive and self disciplined. The worst that teachers can do is to have student sit at their desk, read the introduction and then do the exercise as was noted in this study.

**Has the content in the textbooks satisfied Western Australia’s Outcomes Based Education system at each outcome level according to the child’s development stage?**

To answer the question the Curriculum Framework (1998), Curriculum Framework Curriculum Guide – Mathematics (2005), Curriculum Council Progress Maps (2005), Working Version K–10 Syllabus (2007) and K–10 Syllabus (2007) was used to illustrate the Outcomes as identified by the Curriculum Council at each year of school. A comparison was made with the Statements of Learning for Mathematics (SLM) developed by the Curriculum Corporation (2006).

The concepts and processes used in the Transition textbooks in Number are very important for students in Year 6 and 7. They replicate the K–10 Syllabus and the Curriculum Corporation’s (National) Statements of Learning. Schools should use Transition 1A/B in Year 6 and Transition 2A/B in Year 7 or a similar program that will address the content outlined in these books. Schools with low ability mathematics students would need to modify the content found in Transitions 1A/B to a simpler form and spend more time on reinforcing concepts. To help students understand the Number concepts, teachers should implement processes involving diagrams, the number line and use area concepts to help students arrive at their own rule. This is particularly important for low achieving students in schools. Algebraic symbolism will need to be introduced in primary schools so that students are able to meet the requirement of the SLM and assist them with the New Courses of Study in high schools.
In December 2007, the Department of Education and Training provided teachers with the K–10 Syllabus. The confusion that emanated from their release was the perceived notion that Outcomes Based Education was being replaced and after 10 years, the State had returned to its original curriculum content driven system. The new WA Education Minister Mark McGowan however, reported that the Syllabus was an aid for teachers (Hiatt, 2007, p. 8) and “dismissed suggestions there might be confusion in the education of students taught according to the syllabus and those who were not” (“Syllabus Returns,” 2007). After investigating the K–10 Syllabus in mathematics the first author is of the opinion that there will be differences between students’ learning between teachers using the K–10 Syllabus and those following the Curriculum Framework. The syllabus document specifies content at different years of schooling. It is linked to the SLM and this implies that many of the concepts that were taught in Year 8 and 9 will now be taught in Year 6 and 7. These include algebraic symbolism and formulae. My disappointment was that the Syllabus document in mathematics was not mandated. Many of the problems that were experienced at the high school revolved around the vast differences in students’ content knowledge for each academic group of students. For example in one primary school, the teacher covered concepts involving powers. This is a Year 9 high-level concept and while the academically able students were able to understand the concept, the majority of students in the class were working below the state average and 25% were below the Benchmark. The K–10 Mathematics Syllabus is a good document. Apart from the minor errors that have been noted, its use should be employed in classrooms throughout Western Australia but caution should be exercised. Not all classes and students will be working at the same year level. The class in a Band 2 (low socio economic) primary school should not attempt the same work as a class in a Band 5 (middle–high socio economic) primary school. This then highlights another problem with a National curriculum. There is no assurances a family moving interstate or within the state would transfer to another school in the same band nor have teachers working on the same topic or Outcome.

The books should not be used as the only source of information. While Number content was closely aligned to the K–10 Syllabus and Statements of Learning for Mathematics this was not the case with Space and Chance and Data. Algebra was introduced at Year 7 in Transition 2B, but more would be required if the Outcomes addressed in Statements of Learning for Algebra are to be covered. Teachers implementing this National program in the future would need to be mindful of these differences and be prepared to provide extension work for high achieving students. Prior to extension work being undertaken, teachers need to ensure students have satisfied the statements relevant to each outcome. In many instances students who made the comment the work was easy were not able to demonstrate the Outcome in the tests. Low achieving students would need extra help to ensure they do not continue to be left behind.

Was there an improvement in student’s performance based on WAMSE scores testing when the National pilot program was adopted?

WAMSE scores were analysed from UWA/DET and WALNA testing in this study. At the high school, student results did not show any difference between the 2004/2005 and 2006/2007 cohorts. Teachers were happy using the textbooks and employed many of the diagrammatic approaches used to help students learn mathematics in Number. Teachers believed that student behaviour and attitude to learning, parental involvement and absenteeism impacted on students’ Achievement and Progress in mathematics. With any program these issues would always occur.

In the primary schools, the results varied between classes and schools. The most noticeable change occurred at one primary school were students’ Progress, in the two classes that used the pilot program, had GIRN support and actively involved me in the Teaching and Learning Program, was Moderate or higher. In the class that did not have this support or use the textbooks, the majority of students showed Very Low or Low Progress but this could be attributed to the low number of students having a Year 5 and Year 7 WAMSE score.

There is a need to be cautious when analysing WALNA scores and making generalisations from one test. Student numbers can affect percentages in Achievement and Progress; some students may not be feeling well (as had been noted by teachers in the study) and therefore perform poorly in the test. There is an opportunity for students to guess the correct answer for multiple-choice questions and therefore achieve higher scores than might be expected. At one primary school, the strong union support from teachers had resulted in many students not sitting the WALNA test in previous years and this impacted on the statistics used in the study from this school. Administration at schools needs to exercise caution when distributing these tests to teachers prior to the actual student testing time. Teachers had the opportunity to examine the test questions and consciously or subconsciously review or introduce similar types of questions days before the test. A further concern was reported by one
Principal who made comment that on one testing period a number of years ago, the teacher supported the students to excess during the testing time. This resulted in higher than expected WAMSE scores. For subsequent testing periods, it had a negative impact on the boxplots in Data Club and Progress graphs in First Cut.

CONCLUSION

When the first author initiated this study with the high schools feeder primary schools, the intention was to have consistency in the mathematics program to help teachers at the high school extend on what had been learnt rather than redo the mathematics that may or may not have been done depending on the primary school. This has not been achieved fully because not all teachers were willing to implement change in their teaching program.

Through the schools’ involvement in the ICE–EM program, outcomes include:

- the professional development of nine teachers and their exposure to content that has been outlined in the Statements of Learning for Mathematics and the K–10 Syllabus has been enhanced.
- improvement in teachers’ knowledge in developing students’ mental strategies.
- pedagogical change in some teachers with a shift toward a constructivist perspective.
- renewed teacher interest and enthusiasm for mathematics.
- teacher misconceptions have been addressed.
- a strong partnership with the primary schools students, the administration and teachers has been established.

The information obtained from teachers and students along with observations and discussion with the stakeholders in this study, has provided accountability information to the ICE-EM program coordinators Principals and the District Director. The strength of the Pilot Program has been the consistency of Outcomes covered by the majority of teachers and this has been observed in the Year 8 student cohort in 2008 where students have demonstrated greater understanding of Number concepts. Teachers involved in the pilot program and using the textbooks either partially or fully during 2007 have continued using the textbooks in 2008 and where required have made positive changes in their teaching program utilising the most appropriate textbook for their students.

REFERENCES


514
CONTENT KNOWLEDGE AND SCIENCE TEACHING: HOW CONFIDENT ARE UAE PROSPECTIVE ELEMENTARY SCIENCE TEACHERS?

Hassan H. Tairab
United Arab Emirates University
United Arab Emirates

ABSTRACT

The study investigates UAE prospective elementary science teachers’ content knowledge and their level of confidence in teaching science. A total of 46 prospective science teachers enrolled in elementary program at the College of Education participated in the study. Data collected using specifically designed content knowledge paper and pencil test consisted of thirty multiple-choice questions and a questionnaire to explore participants’ perceptions and confidence about aspects of skills and content knowledge related to teaching. The findings suggest that prospective elementary science teachers may well need further background in scientific knowledge presented at a level that correspond to their beliefs and confidence. Although participants felt they were more confident about aspects of teaching science in elementary schools, they demonstrated weak content knowledge of the aspects that were regarded as core components of content knowledge. Implications of these findings were offered suggesting the importance of incorporating the knowledge base science into science methods courses to ensure the development of content knowledge by prospective science teachers.

INTRODUCTION

Recent science education reforms in the United Arab Emirates have focused among other things, on the role of science teachers in shaping the future development of the country. The main theme of the UAE reforms proposed promising goals for the future and direction of science education. Among the frequently stated reform themes appearing in most of the recent curriculum documents is to prepare teachers as professional practitioners who are capable of helping students acquire the scientific and technological literacy so that they can have better future choices, lifelong learning skills, and consequently better living standards. Indeed, this has proven to be a major challenge for current science education reform activities. To increase science understanding of elementary teachers while providing them with strategies and techniques for teaching science effectively to support and enhance their students’ science understanding requires not only reforming existing programs but also developing theory and research based knowledge for teacher education programs and to determine the extent to which science teacher education programs focus on covering and developing scientific literacy among the prospective science teachers and assess how well these programs effectively support the attainment of those specified learning goals.

Increasing teachers' content knowledge of their discipline and their expertise in pedagogical content knowledge is both challenging and overwhelming to many educators. In elementary education, for example, the lack of strong content knowledge in science is particularly evident. Worldwide many researchers have shown that the quality of teachers' subject matter knowledge affects their ability to effectively conduct inquiry-oriented investigations in science classrooms (Petish & Davis, 2001). In addition, the goals these teachers choose for their students during instructional planning and the factors that affect these decisions may affect their ability to teach effectively (Borko & Niles, 1987).

There have been many educational research studies performed in an attempt to ascertain the depth of preservice science teachers’ subject matter knowledge (Cochran & Jones, 1998). Early attempts to systematically define effective teaching explored the relationship between teacher knowledge and student achievement. In these early attempts relationships were sought between a number of variables such as type of courses that teachers took and their grade point averages and student learning. More recently similar extensions of this type of studies have been undertaken, matching preservice teachers’ academic performance to their teaching performance.

Whereas early attempts to define subject matter knowledge were based on specific quantifiable measures, new conceptualizations were portrayed using new approaches. Goals such as science literacy for all students, integrated understandings of the unifying concepts within a discipline, and participation in the discourse about knowledge construction have been adopted to replace the more simplistic indicators of knowledge such as national test scores, and rates of course completion (National Research Council, 1996; Gess-Newsome, 1999).

A fairly consistent portrait has been painted that illustrates teachers’ lack of deep content understandings in all science subject areas. A number of scholars have examined the impact science teachers’ content knowledge has on their ability to teach science effectively. For example, elementary science teachers have been found to possess
prospective science teachers at UAE context. Specifically, the research examines the prospective science teachers' student achievement (Love & Kruger, 2005). These practices in turn, may shape the dynamics of student learning and assessment of teachers' content knowledge and confidence could be translated into classroom instructional practice programs designed to enhance teacher competence in science education. Knowledge base generated from such prospective science teachers' content knowledge and confidence levels is an important consideration in restructuring specific to curricular topics are scarce, particularly those at the UAE context. While research studies acknowledge the importance of teachers' confidence about teaching science, studies generally low level conceptual and factual knowledge as well as inadequate skills in the content area of science (Wenner, 1993; Jegede, Taplin & Chan, 2000; Kallery & Psillos, 2001; Justi & Gilbert, 2002; Abd Rahman, 2004; Calik & Ayas, 2005). In particular, researchers have discovered that teachers often lack deep, integrated understandings of science content (Cochran & Jones, 1998), hold alternative conceptions concerning science topics which are similar to the ones their students may possess (Ginn & Watters, 1995), and utilize scientific terminology that they do not truly grasp (Darwin, 2006). Elementary teachers, in particular, tend to have less science content knowledge than do their peers who teach secondary science (Anderson & Mitchener, 1994). Smith and Neale (1989) analyzed the ways in which content knowledge impacted the science lesson planning of ten inservice elementary teachers. They concluded that teachers with poor content knowledge often did not involve students in the various components of scientific inquiry such as making predictions or designing investigations. Furthermore, the teachers tended to shape students' alternative ideas about science instead of probing for understanding. Carlsen (1987) examined the quality of preservice secondary biology teachers' classroom discourse and found that when teachers were unfamiliar with the content they tended to close down classroom conversations, closely follow the textbook, take discussions on unproductive issues and delay instruction at the beginning of class. Similarly, Lee (1995) conducted a case study analysis on a secondary science teacher's practice and found that her low quality content knowledge negatively influenced the instructional strategies she employed. The teacher studied by Lee (1995) relied heavily on independent seatwork derived from the textbook and avoided whole class and group activities.

While at the elementary or the secondary level, because of their lack of content knowledge, preservice teachers may lack confidence in their ability to teach science. Anderson and Mitchener (1994) described pre-service elementary teachers' knowledge of science as limited in amount, narrow in perspective and characterized by lack of understanding, while Ball and MacDiarmid (1990) suggested that, in general, the subject matter knowledge of the teachers at elementary levels is grounded in everyday experience and in their educational experiences occurring prior to post-secondary education.

It appears from the above research findings that lack of a strong background in science content knowledge significantly contributes to hesitancy and possible inability to deliver effective science instruction in classroom settings. Indeed, previous research in this area found that teachers gravitate towards performing those tasks in which they feel confident and competent (Johnson & Hall, 2006). A research study curried out by Holroyd and Harlen (1996) with elementary school teachers showed that, in the majority of cases, there is a positive correlation between levels of confidence about teaching the subject and understanding in the context of science. Wenner (1993) also found that elementary teachers have low levels of science knowledge overall and less confidence in the ability to teach science. In the same context a research study of Osborne and Simon (1996) showed that the level of the subject knowledge affected the process of organizing, implementing and delivering tasks.

Lack of confidence in science often results in a resistance to teaching science in dynamic and engaging ways. In science education, the problem becomes cyclic with the absence of a strong content knowledge background fueling resistance both to teaching science to students meaningfully and to learning more about science as professional educators keep abreast with recent scientific development.

Content knowledge of science is obviously fundamental to being able to help students learn. Lack of scientific understanding at a conceptual level is thought to be particularly troublesome for elementary science teachers who need to teach fundamental concepts to young students. To communicate an accurate understanding of scientific knowledge to students, science teachers need to understand the subject matter from multiple perspectives than that actually presented to the students. To teach as advocated by most science education reforms, teachers must hold deep and highly structured content knowledge that can be accessed flexibly and efficiently for the purposes of instruction (Sternberg & Horvath, 1993). Such knowledge will be essential in order to teach for understanding and to provide authentic learning opportunities for students (Gess-Newsome, 1999). Teachers need to understand the structure and nature of their discipline, have skill in selecting and translating essential content into meaningful learning activities, maintain fluency in the discourse of the community, and recognize and highlight the applications of the field to the lives of their students.

While research studies acknowledges the importance of teachers' confidence about teaching science, studies specific to curricular topics are scarce, particularly those at the UAE context. Assessment therefore of both prospective science teachers' content knowledge and confidence levels is an important consideration in restructuring programs designed to enhance teacher competence in science education. Knowledge base generated from such assessment of teachers' content knowledge and confidence could be translated into classroom instructional practice (Stuart & Thurlow, 2000; Deemer, 2004). These practices in turn, may shape the dynamics of student learning and student achievement (Love & Kruger, 2005).

The present research therefore aims at exploring the extent of content knowledge and confidence level of prospective science teachers at UAE context. Specifically, the research examines the prospective science teachers'
beliefs about their content knowledge level; and their confidence level regarding their ability to affect science teaching and learning among elementary students.

RESEARCH METHODOLOGY

Participants

The participants in this study were prospective elementary science teachers enrolled in an undergraduate elementary education program at the College of Education of the United Arab Emirates University. A total of 46 elementary prospective science teachers were included in this study. All participants are females and were in their final semester of the study at the time when they responded to the questionnaire and were already undertaking their teaching practice course in schools as the final components of their teacher education program. All participants have completed science content courses at the level of general chemistry 1 and 2, general physics 1 and 2, basic biology, plant biology, physical geology, in addition to other elective related courses such as animal biology and analytical chemistry.

Instruments

The data for this study were gathered by a questionnaire to assess participants’ confidence in teaching science and a content knowledge test. The questionnaire was developed from various related sources such as the conceptual framework recently adopted by the College of Education of the United Arab Emirates and the literature on teachers’ beliefs and teachers’ confidence. The COE conceptual framework constitutes all principles, values, and concepts that make up all different levels of teacher preparation program. It is considered to be an umbrella covering all stages of teacher preparation program starting with the candidate’s joining the college and ending with the candidate as a professional practitioner. It reflects the UAE context, values, and beliefs and informed by the internationally recognized standards of teacher education professional organizations.

Abiding by its vision and striving to achieve its mission, the College of Education works on preparing qualified teachers adopting the theme “Teacher as Professional Practitioner”. To achieve this, the conceptual framework focuses on a set of 12 elements to guides its programs and eventually the development of learning materials for these programs. The content knowledge ability in the specialization, the ability to be a reflective practitioner, inquiry oriented, a critical thinker, understand diversity and ethical teaching and professional issues are among the elements that are stressed and included in the college conceptual framework.

The questionnaire

The questionnaire used in this study consisted of statements that describe how the participant’s feel about aspects and knowledge of teaching science, and about their views on their confidence in teaching specific science content. Prospective science teachers’ confidence is defined in this research as the extent to which prospective science teachers believe they have the capacity and the ability to positively affect students learning through their ability to demonstrate the skills and the teaching aspects mentioned in the questionnaire statements.

The questionnaire consists of 44 statements representing various teaching skills and competencies and confidence in teaching specific content area. The first 26 statements were divided into 4 broad categories namely, knowledge of use of instructional techniques; knowledge of content representation; knowledge of student understanding; and knowledge of curriculum and teaching goals. The 26 items cover the four categories of teaching skills and content as follows:

<table>
<thead>
<tr>
<th>Category of skills and competencies</th>
<th>item</th>
</tr>
</thead>
<tbody>
<tr>
<td>knowledge of use of instructional techniques</td>
<td>1, 5, 7, 13, 15, 19, 22</td>
</tr>
<tr>
<td>knowledge of content representation</td>
<td>3, 16, 17, 18, 20, 23</td>
</tr>
<tr>
<td>knowledge of student understanding</td>
<td>8, 9, 10, 11, 21, 25</td>
</tr>
<tr>
<td>knowledge of curriculum</td>
<td>2, 4, 6, 12, 14, 24</td>
</tr>
</tbody>
</table>
Participants were asked to indicate their responses along a 4-point scale ranging from 1 to mean very low confidence in demonstrating the stated category to 4 meaning that the participant has a very high confidence in the demonstrating the stated skill. The remaining 18 statements deal with participants' confidence in specific science content area. The sciences content areas were taken form the UAE elementary science curriculum, which these prospective teachers were engaged in teaching to their elementary school students.

A panel of three university professors in science education reviewed the questionnaire for relevance and suitability for the purpose of the study. The questionnaire was field tested with a group of 20 elementary education undergraduates and then modified for clarity, organization, and content based on feedback from those individuals. The calculated Cronbach alpha reliability of the questionnaire for the main study was found to be 0.76, which was deemed to be suitable for the purpose of the study.

Content Knowledge test

The Content Knowledge test was designed to assess the scientific knowledge and skills necessary for prospective science teachers after completing all theoretical aspects of their teacher education program. The development of the test questions and the construction of the test reflect the related elements of the conceptual framework upon which the teacher education program of the college of education is built.

Thirty multiple-choice questions that assess knowledge of fundamental scientific concepts, principles, phenomena, and scientific processes were developed. These items were chosen due to their alignment with the College of Education core knowledge standards and because they are used as the benchmarks for domain specific knowledge of students existing the elementary teacher education program. Table 2 shows the domains that make up the questions.

<table>
<thead>
<tr>
<th>Content Categories</th>
<th>Number of Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>7</td>
</tr>
<tr>
<td>Chemistry</td>
<td>8</td>
</tr>
<tr>
<td>Physics</td>
<td>7</td>
</tr>
<tr>
<td>Methodologies</td>
<td>8</td>
</tr>
</tbody>
</table>

In general, the test questions focus on participants' ability to comprehend critical concepts, apply scientific knowledge, and analyze content to address and solve problems that at the heart of the elementary education program. The test also covers scientific methodology and processes expected to be mastered by the elementary science teachers. The test questions cover topics that prospective science teachers would have studied at college-level courses in science as well as those examined in the elementary school curriculum. The test was divided into sections that focus on biological, physical, chemical, and procedural knowledge. Content validity was established by a panel of three science education university professors through careful mapping of test questions to curricula content and elementary education program goals. Reliability of the test was determined to be 0.78 using Cronbach's alpha for the study sample.

RESULTS

Descriptive statistics were used to analyze the research instruments (content knowledge test and the questionnaire). Means, standard deviations and standard errors of measurement are given in Table 3 and 4 for the content knowledge test and in Table 5 – 8 for the confidence questionnaire.
Table 3  
Descriptive Statistics of Content Knowledge Test

<table>
<thead>
<tr>
<th></th>
<th>Mini</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology</td>
<td>2.00</td>
<td>6.00</td>
<td>3.91</td>
<td>1.24</td>
<td>0.18</td>
</tr>
<tr>
<td>Chemistry</td>
<td>2.00</td>
<td>7.00</td>
<td>4.13</td>
<td>1.18</td>
<td>0.17</td>
</tr>
<tr>
<td>Physics</td>
<td>0.00</td>
<td>6.00</td>
<td>3.45</td>
<td>1.25</td>
<td>0.18</td>
</tr>
<tr>
<td>Methods</td>
<td>1.00</td>
<td>7.00</td>
<td>4.04</td>
<td>1.50</td>
<td>0.22</td>
</tr>
</tbody>
</table>

It can be seen from Table 3, that a relatively low mean score of 15.52/30 (SD = 4.47) correct responses on the content knowledge test, the standard error of measurement was 0.65. The average student, therefore, provided correct responses to about 50% of the questions. This result can be described as disappointing in that prospective science teachers preparing to teach science at basic levels lack the mastery of the content they teach. Several studies found a similarly low level of science knowledge among preservice elementary teachers (Wenner, 1993; Jegede, Taplin & Chan, 2000; Kallery & Psillos, 2001; Justi & Gilbert, 2002; Abd Rahman, 2004; Calik & Ayas, 2005).

Table 4  
Descriptive Statistics of Content Knowledge Test by Domain

<table>
<thead>
<tr>
<th>Content area</th>
<th>Mini</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biology section</td>
<td>2.00</td>
<td>6.00</td>
<td>3.91</td>
<td>1.24</td>
<td>0.18</td>
</tr>
<tr>
<td>Chemistry section</td>
<td>2.00</td>
<td>7.00</td>
<td>4.13</td>
<td>1.18</td>
<td>0.17</td>
</tr>
<tr>
<td>Physics section</td>
<td>0.00</td>
<td>6.00</td>
<td>3.45</td>
<td>1.25</td>
<td>0.18</td>
</tr>
<tr>
<td>Methods and skills</td>
<td>1.00</td>
<td>7.00</td>
<td>4.04</td>
<td>1.50</td>
<td>0.22</td>
</tr>
</tbody>
</table>

When the test is analyzed by subject area categories (Table 4), the average student obtained about 56% correct responses for the biology questions, 51% for the methodology section, 51% for the chemistry section, and 49% for the physics section. This study supports other studies in demonstrating weakness in prospective teachers' content knowledge in the areas of science. Given that the percentage of correct responses in the content knowledge test ranged from 49% to 56% participants' general understanding of science concepts may be questioned.

**Teaching confidence**

Participants' self-assessed levels of confidence in an ability to teach science seem somewhat incongruent and inconsistent given the level of confirmed content knowledge revealed in Tables 3 and 4.

Table 5 shows that the prospective science teachers may be seen to indicate a generally high degree of confidence in their personal knowledge of using a variety of instructional techniques, incorporating the use of hands-on materials in teaching, incorporating technology related tools in instruction, and facilitating student learning using a collaborative teaching environment. Mean score for these competencies is greater than 3.00 meaning that teachers are either moderately or very confident in their ability to carry out stated competencies. This high level of confidence in performing the mentioned teaching competencies does not match the somewhat lower scores obtained in the content knowledge test.
Similar trends appear in Table 6, with prospective science teachers exhibiting moderate to high level of confidence in planning and developing teaching and assessment activities to their students. However, the expressed level of confidence in personal ability to plan assessment tools that assess practical investigations does seem to be consistent with their content knowledge understanding as their self-assessed result indicates participants exhibit slight confidence in this competency.

Table 6
Descriptive Statistics of Planning Competencies Confidence Category

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mini</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of how to select learning outcomes</td>
<td>3.00</td>
<td>4.00</td>
<td>3.47</td>
<td>0.50</td>
<td>0.07</td>
</tr>
<tr>
<td>Developing assessment tools to measure learning</td>
<td>2.00</td>
<td>4.00</td>
<td>3.10</td>
<td>0.64</td>
<td>0.09</td>
</tr>
<tr>
<td>Development of scientific experiments or investigations</td>
<td>1.00</td>
<td>4.00</td>
<td>3.13</td>
<td>0.93</td>
<td>0.13</td>
</tr>
<tr>
<td>Development of lesson activities that address specific content</td>
<td>2.00</td>
<td>4.00</td>
<td>3.26</td>
<td>0.61</td>
<td>0.09</td>
</tr>
<tr>
<td>Developing assessments that measure students' ability to conduct investigations</td>
<td>1.00</td>
<td>4.00</td>
<td>2.95</td>
<td>0.81</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Indicators of confidence reported in Table 7 revealed some uncertainty on the part of these prospective teachers. While participants indicated a confidence in their knowledge of integrating science curriculum with other subjects, for example, their ability to determining the depth, breadth, and pace of coverage of materials when teaching, and knowledge of the local curriculum goals have shown less confidence on the part of participants.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mini</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determining the depth, breadth, and pace of coverage of materials when teaching</td>
<td>1.00</td>
<td>4.00</td>
<td>2.97</td>
<td>0.88</td>
<td>0.12</td>
</tr>
<tr>
<td>Integrating science with other subjects when teaching</td>
<td>1.00</td>
<td>4.00</td>
<td>3.13</td>
<td>0.89</td>
<td>0.12</td>
</tr>
<tr>
<td>Knowledge level of Ministry educational goals</td>
<td>2.00</td>
<td>4.00</td>
<td>2.89</td>
<td>0.79</td>
<td>0.11</td>
</tr>
<tr>
<td>Prepare student for the kind of expectations they will encounter in the future</td>
<td>2.00</td>
<td>4.00</td>
<td>3.26</td>
<td>0.64</td>
<td>0.09</td>
</tr>
</tbody>
</table>

Measures of prospective science teachers' confidence in their ability to know their students and their characteristics are reported in Tables 8. With the exception of ability to facilitate student investigations with the entire class of students, participants show moderate to high level of confidence in developing student abilities to evaluate and analyze results, responding to student inquiries during student investigations, developing student interest in science, demonstrating knowledge of student characteristics, and maintaining interest and motivation of the students.

These and other data found in Tables 5 - 8 lead to the conclusion that while the prospective science teachers are generally confident in their teaching competencies, they harbor doubts concerning their ability to teach at a conceptual level or to conduct process-oriented, hands-on experiences in classroom settings. This is because process oriented teaching, active presentations and hands-on experiences require conceptual understanding of curriculum content, and processes. These results fit with previous confidence research findings that explaining teaching as having an effect on personal prestige and self-confidence.

As one might reasonably expect to find a relationship between higher levels of subject-matter knowledge and teachers’ confidence to teach, the findings of this study do not support this assumption. It can be argued that content knowledge, confidence in one's ability to teach scientific content, and willingness to assume responsibility for student learning represent the three essential components of science teaching at the elementary level.
Table 8
Descriptive Statistics of Knowledge of Student Confidence Category

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mini</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
<th>S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitating students investigations with the entire class of students</td>
<td>2.00</td>
<td>4.00</td>
<td>2.97</td>
<td>0.80</td>
<td>0.11</td>
</tr>
<tr>
<td>Developing student abilities to evaluate and analyze results</td>
<td>2.00</td>
<td>4.00</td>
<td>3.00</td>
<td>0.63</td>
<td>0.09</td>
</tr>
<tr>
<td>Responding to student inquiries during student investigations</td>
<td>2.00</td>
<td>4.00</td>
<td>3.32</td>
<td>0.70</td>
<td>0.10</td>
</tr>
<tr>
<td>Developing student interest in science</td>
<td>2.00</td>
<td>4.00</td>
<td>3.43</td>
<td>0.65</td>
<td>0.09</td>
</tr>
<tr>
<td>Demonstrating knowledge of student characteristics</td>
<td>3.00</td>
<td>4.00</td>
<td>3.71</td>
<td>0.45</td>
<td>0.06</td>
</tr>
<tr>
<td>Maintaining interest and motivation of students</td>
<td>2.00</td>
<td>4.00</td>
<td>3.43</td>
<td>0.68</td>
<td>0.10</td>
</tr>
</tbody>
</table>

Confidence in teaching content area

Finally, prospective science teachers’ confidence in the content knowledge they teach was also assessed. Participants seemed generally confident in their knowledge of content areas taught at elementary schools. Although participants felt they were more confident about aspects of teaching science in elementary schools, they showed mixed perceptions about some of the aspects that were regarded as core components of content knowledge and effective teaching. Mostly participants felt they were very confident about teaching physics related content, yet their own physics content can be questioned judging by their performance in the content knowledge test. Relationship can also be drawn as regard to their actual content knowledge, content knowledge of their preparation program and their confidence. It seemed from the results that content studied in the teacher education program has raised personal confidence but not personal content knowledge. It certainly evident here that these participants over assessed their ability in teaching elementary education science content.

DISCUSSION AND CONCLUSION

This study supports the findings of previous research studies (Wenner, 1993; Jegede, Taplin & Chan, 2000; Kallery & Psillos, 2001; Justi & Gilbert, 2002; Abd Rahman, 2004; Calik & Ayas, 2005) in finding a generally weak knowledge base in science among prospective teachers. Reconciling the beliefs expressed by these participants regarding their ability to affect science teaching and learning among elementary students with this demonstrated level of science understanding will no doubt require further exploration. The results clearly suggest that prospective elementary science teachers may well need further background in scientific knowledge presented at a level that correspond to their beliefs and confidence levels.

Furthermore, the results suggest a need for a reflective intervention during teacher education programs to raise the content aspects of these prospective teachers. The content knowledge test results suggest a negative relationship regarding personally expressed confidence in ability to teach science materials suggesting that affective issues need to be taken into account in preparing science instruction for these prospective teachers. Results from this study would also indicate that these prospective science teachers hold a relatively positive self-image regarding general ability to teach regardless of their lack of in-depth understanding of subject matter content knowledge.

Since there will be a need for prospective science teachers to improve their understanding in subject matter knowledge, the results of this study might well indicate a need for collaborative efforts between science specialists.
and science education specialists in devising ways in which teacher education preparation programs might better serve the needs of prospective teachers. Lacking this effort the question of teachers’ adequate conceptual understanding of content knowledge and consequently conceptual presentations would remain unanswered.

It seems that meaningful changes need to be introduced in teacher education program preparation. Stressing the organization of content knowledge at the conceptual level and delivering instruction emphasizing student learning has been recommended (Cochran & Jones, 1998) and is further supported by the results of the present search. The results also might point to the importance of incorporating knowledge base science into science methods courses to ensure the development of content knowledge by prospective science teachers.

Certainly the recent introduction of content and pedagogy development courses as part of the elementary education program package will no doubt lead to alleviate the problem and put the elementary teacher education programs on the right track. However, taking the relatively low enrollment of prospective elementary science teachers, the effectiveness of the content and pedagogy development courses will still remain to be seen and may require different methodological approaches in order to establish its effectiveness.

If such content knowledge deficits among elementary teachers and their confidence levels are to be taken seriously by educators, increasing the level of comprehension of science concepts among prospective elementary education students would be a worthy goal for teacher education programs. As prospective science teachers begin to better understand and organize science content, knowledge, their teaching practices and consequently their student outcomes might be expected to change.

REFERENCES


INTERNATIONAL FIELD SCHOOLS AS INTERNATIONAL EDUCATION: AN ETHNOGRAPHIC APPROACH

Andra P. Thakur
Udon Thani Rajabhat University, Thailand

What a man sees depends both upon what he looks at and also what his previous visual conceptual experience has taught him to see. In the absence of such a training there can only be in William James’ phrase ‘a blooming buzzing confusion’.

-- Thomas Kuhn; The Structure of Scientific Revolution.

INTRODUCTION

The purpose of this paper, with the aid of photographs (see Appendix I), is to discuss the social, academic and cultural utility of International Field Schools among University students from Malaspina University-College in Nanaimo, B.C. Canada. The data is drawn largely from my personal experiences of the nine Field Schools I have conducted in South and South East Asia, the Caribbean, and South America between 1994 and 2004 and influenced by my own field research experiences in the Caribbean and West Africa. Our field/discipline of concentration is Anthropology, with an ethnographic approach, where students are encouraged to draw from their own cultural experiences as well as from their hosts’ cultures in order to draw conclusions.

The question is often asked; why Field Schools? A simple answer could be; why not Field Schools? Field Schools offers our senior undergraduate students the opportunity of an early exposure to, and the experiencing of, another culture while acquiring credits towards their degree. It is a hands-on experience and a supplement to text-book and class-room information.

One of the most severe criticisms of anthropology, and among anthropologists themselves, is to be called an “arm-chair anthropologist”. As a result significant emphases have being placed on Field Work, where one spends lengthy periods of time living and studying peoples and cultures in their own settings. This emphasis on Field Work has been laid down by the pioneers in the field: Malinowski among the Trobrianders; Boas among the Inuit and Mead among the Samoans. However, one simply does not enter the field and start collection information or data; it requires a process of socio-psycho-cultural transformation. A ritualize transformation perhaps? Drawing from Srinivas’ concept of “thrice born”, Spindler states that:

One is born into one’s own culture and enculturated within it… [upon entering the field, that is] studying outside one’s own culture, one is “born again”—one must learn a new culture—and learn to “think like a native” (albeit imperfectly). Making the strange familiar, or familiarizing the exotic, is done both in the field and in one’s interpretation. Upon our return to our native land, we are born for the third time as we refamiliarize ourselves with what has now become exotic but was once familiar (Spindler 1988: 491).

These three stages as articulated by Spindler are necessary preconditions experienced by all students going into the field. First, being born into our own cultures and through the enculturation process we acquire the rules, both formally and informally, which govern the patterns of our behavior; the norms and mores by which we adapt, the process by which we recognized the sacred from the profane, the unspoken symbols of dos and don’ts, rights from wrongs, along with all the accompanying subtle cultural nuances. By this enculturation process we become unconsciously aware of our cultural dictates, which we often take for granted.
Second, when we enter or “take birth” in another culture, we are constantly searching for the cultural lamp-post that would guide us in our daily social intercourse. As, at first, we are displaced. We strive not to trespass or violate the rules of host cultures. Importantly, we struggle to comprehend the emic (inside) world of the other—the unspoken realms of their inner thoughts and feelings, even their hopes and aspirations. Third, upon our return home our own cognitive and cultural map has been somewhat shifted. Our own values of politics, religion and even morality have become somewhat blurred or shifted. We began to see defects or even exaggerated importance, in things we once took for granted or even ignored. In short, the process of going through the three births; that is of our own, that of another and the re-entering of our own again, provides the opportunity for the evolution of a more global and cross-cultural equilibrium.

Because of economic consideration, Field Schools are relatively short—usually six weeks and are divided into three segments. First, pre-session readings. Where, prior to Field Schools, students are introduced to readings in ethnographic materials from host cultures. Second, formal class-room lectures. The first three weeks are set aside for lectures, and exams based on assigned readings. Third, visits to ethnographic sites. In the field, there are no limits to ethnographic sites; a village, a market place, a grave yard, a garbage dump, a ritual, a class-room, a festival or monument comes readily under the microscopic eye of a trained ethnographer. Further, because of the relatively short duration, students do not have the luxury of time to fully immerse in their host cultures. It has been our intention that Field Schools will not only wet the intellectual appetite of our students but importantly contribute to the development of a high level of cultural sensitivity.

Field Schools are much more than scholarship: it is a way of preparing students for global citizenship (see Appendix II); a better understanding of how another culture evolves and sustains itself under different socio-ecological and environmental conditions; a way of mitigating against ethnocentric biases; a basic understanding of another language—other than their own. Importantly, Field Schools provide the opportunity of learning of seeing “the other” as non-threatening. Seeing (observing) and living (participating) in another culture provides the opportunity for students to reflect on their own. One student from Missouri Southern State College, in the United States commenting on her field school experiences in Japan stated that “we had the chance to meet some great people…that I would not soon forget. Their kindness had me thinking, though, would they get the same treatment if they come here [U.S.]? I am not sure…. Americans are raised speaking English, and only English… When one steps outside of the U.S one can see how much knowledge is out there (see Change: May/June 2002: 45-51)” From this statement we can deduce that, through International Field School, one American student has began to reflect that America is not the centre of the world, my country is not always right, and that we do not know it all.

AN ETHNOGRAPHIC APPROACH

An ethnographic approach is basically a methodological approach. It is the study of the world of a people. It is one method by which data in the social sciences is collected; it is qualitative in nature and does not include cumbersome statistics-- hence it is descriptive. Wilcox (1988: 458-59) says that the goal of an ethnographer should be three-fold. First, every researcher must set aside their own ethnocentric preoccupation and view the community as perceived and acted upon by its participants. Second, in conducting research in one’s own community, one is trying to make the familiar strange; “that which is taken for granted by the researcher or by the participants, to assume that that which seems commonplace is nonetheless extraordinary and to question why it exists or takes place as it does, or why something else does not”. Third, to comprehend why things are, the way they are, and that the researcher must look at the relationship between the setting and its context; that nothing is static, and that nothing exist in and by itself. In short, one acquires the skills of seeing the tree and the forest simultaneously, that is the inter-relationship of the parts that constitutes the whole.

Many early ethnographic researches, including Mead’s works among the Samoans, have been subjected to severe criticisms. So too, is the relatively recent research carried out by Napoleon Chagnon among the Yanomamo of Brazil and Venezuela. Despite these criticisms, there is sound academic utility to ethnographic research and one does not throw away the baby with the bath water. David Suzuki, the well known Canadian scientist, has repeatedly stated that ‘it is the business of today’s scientist to prove yesterday’s scientist incorrect”. Suzuki has been alluding to the fact that compared to their predecessors; today’s scientists have a far more refined tool kit, at their disposal, for analysis.
Schools, or for that matter, the educational system are seen as both, agents of continuity and change. However, the school system throughout the world and more so in the metropolitan parts of the Western world, is saddled with tension at one end and extreme violence at the other. This occurs despite the enormity of the material and human resources injected into it and the liberal input from individuals such as; Illich’s attempt in Mexico, Neil’s Summerhill model in England or the more popular Montessori model.

What are the contributing factors to the educational problems? A school system is made up of several component parts. The sixty-four thousand dollar question is: do these parts operate as an integrated community? On the one hand we find that there are scores of educational bureaucrats, sitting in the urban-metropolitan offices, designing a curriculum to meet the educational needs of a native/poor student living in a remote village or an urban ghetto. On the other hand there are parents, living in an urban ghetto, who finds it impossible to identify with the merits of education and with the educational system. Thus, there are inherent built-in contradictions among the key stakeholders. Mediating between the rural/remote or ghetto students and urban educational bureaucrats are the teachers—headed by a principal. Are the values expounded by the teachers those of the curriculum, or are they of the students and their parents? The tension arises because, within the educational system, there exist several, and often, contesting communities. An ethnography of education would readily recognize the contesting communities within the system (see Peshkin 1988: 50-67). At best students would respond partially, and only partially, to an educational system in which he/she feels alienated, Role models are far and few in between.

It is within this ethnographic perimeter that we choose the use four photos, from our Field School locations: (1) Rural India; (2) Balinese Cock Fight; (3) Thailand: Post Harvest Lunch; and (4) Guyana: Overseer’s Quarters, to demonstrate their socio-cultural and academic functions as international education.

1 RURAL INDIA

The general theme of this photo is of women, with the use of straw, covering heaps of cow-dung. This is done to prevent the evaporation of the moisture from the dung, as well as to prevent its erosion from rainfall. In rural Northern India it is relatively easy to tell the socio-economic status a family simply by looking at the amount of cow-dung that is heaped in front of the homes. The amount of cow-dung denotes the amount of cattle (cows and buffaloes) owned by the household. Taking into consideration their reproductive power, as well as their and economic utility, cattle is often banked in the form of wealth: a cow produces a calf; which in turn reproduces. Cattle is still the principal source for of traction energy in the agrarian sector in India; a renewable and appropriate technology which is and ecologically sustainable. Modern, urban and technological India seems to turn a blind eye to it.

Cow-dung is used in a myriad of ways: in the winter months it is used as a direct source of heating (especially for the poor) fuel for cooking; as bio-gas for cooking, as fertilizer; and as a sacred source for daubing a spot when performing a Hindu ritual.

As denoted by the quality of their costumes the women are relatively wealthy and the covering of their heads suggests that they are all married which is a matter of respect, especially for elderly male in-laws. Rural India is strongly patriarchal and patrilocal.

2 BALINESE COCK FIGHT

My own interest in Geertz’s work is not so much in cock fighting but on his classic, Agricultural Involution. However, his ethnographic works on Cock Fight seems to have had a much wider appeal and he has been credited as one of the principal contributor to his Symbolic Integrationist Theory.

It is generally agreed that cock fight is a Balinese pastime. It is a blood sport and cocks would often fight to death or until permanently disabled. This is done with the aid of razor-sharp blades attached to spurs of the cocks. My own reading of it is that in discussing cock fight, Geertz was employing George Orwell’s Double Speak. Would the term/concept roaster convey any less a meaning than cock? During my first visit to Bali, and in several personal communication of “men and cocks”, I observed that “men, in the afternoon, can be seen walking around with their cock in their hands looking for a fight” … “A man with a good cock can earn as much as a week’s wage in an afternoon”. Further, has Geertz misinterpreted the symbols or exaggerated them? Cock fight is an integral part of
Balinese culture, albeit a male preoccupancy. I did not observe the “symbolic” violence of cock fight in Balinese society, though the idea of shame to the vanquished and honor to the victor is quite overt. However, is this not also true of all societies and cultures where games, and particularly sports, are highly competitive? Another relevant point that require critical investigation is that Bali is the only Hinduized society/culture in a predominantly Islamic Indonesia. The violence that has been prevalent in other parts of Indonesia has, until relatively recent, been absent in Bali. If this is a factor then any broad and sweeping generalization of Bali to the rest of Indonesia could be misleading.

Cock fight is a sport and Balinese men treat it with little or no difference from the way us, in the West, treat horse racing. We go at great length to win—including illegal acts. Cocks are bred for fighting and in the process they are trained, including special, physio and psycho-therapy; massaging, talking to, coaxing and cajoling. Cock fight is illegal and so is gambling associated with it. It seems that Balinese—especially rural ones—would find any reason or excuse to gamble. I once observe them betting on a random beetle race.

3 THAILAND: POST HARVEST LUNCHON

During the harvest season I was invited to harvest the field we had transplanted. After the morning’s work we sat down for lunch and, as can be seen from our clothing, it was an extremely hot day. Here too, the technology employed in harvesting is the simple sickle and the grains are separated from the straw by simply thrashing it on the ground.

The photo is made up exclusively of eight men; myself, six sons-in-law and the father-in-law. The six sisters and mother are seated in the kitchen. The familial organization is both matrilineal and matrilocal, where names and property are inherited through the mother’s line, but they do not share a common household. The land is owned and worked jointly by the mother and sisters (with male help), and the harvest is divided accordingly. From his costume we recognize that the gentleman in the foreground is not in his “field” attire. He is a son-in-law, but not a farmer, and works as a chauffeur with Thai Tourism.

4 THE OVERSEER’S QUARTERS.

Unlike the United States, the history of plantation economies in the Caribbean have been literally and figuratively closed communities—outsiders are not allowed in and insiders are not allowed out. An apartheid-like relationship existed. My grandfather, from India, was an indenture labor from 1912-22, at plantation Albion, and lived there until his death in 1956. My father was born there and so was I. The house, as well as the fence, is symbolic of power and authority

This sugar plantation was owned by the London based Bookers Brothers Mc. Connell and Co. The white manager and overseers lived separately from the (mostly) East Indian laborers who live in lodgies once occupied by former slaves. Only the younger European children lived with their parents. Once they reach school-age children are sent to school in England or Scotland.

This photo was taken in 2007 (by V. Ramcnand). When I started running away from home to school (1943) there was a white picket fence. The gate did not exist; as there were no cars and the overseers rode on mules. Here is a summary of my article “The Other Side of the Fence”. As I was passing the overseer’s quarters, through the white picket fence, I saw a little white boy. He was about my age (three and a half) and I was immediately struck by the whiteness of his skin. He was neatly dressed: his white shirt neatly tucked in his trousers; his short trousers neatly creased, with shoes socks and all. I was barefooted and certainly in tattered clothes. I stopped. We caught each other’s attention. I moved closer to the fence. So did he. We stared at each other for what seems like eternity. Maybe that is why I continue to see him (see Roberts et.al 1999: 10).

CONCLUSION

Organizing a Field School is time consuming but the joys of traveling, learning and sharing with students can never be overstated. All cultures have acquired mal-adaptive strategies-- clitoridectomy, caste system, sexism and sexual violence, persistent poverty, terrorism, racism, plural marriages. Students on International Field Schools seeing these
problems from within perceived them with another lens, both for interpreting and countering. A cultural relativist or an emic perspective does not mean that one agrees with mal-adaptive cultures. What they seek to do, besides preparing students for global citizenship, is also to provide them with more effective tools to counter cultural mal-adaptation—both theoretically, as well as applied.

REFERENCES

APPENDIX II

REFLECTIONS FROM FORMER FIELD SCHOOL STUDENTS

In March 2004, while still a faculty member at Malaspina University-College, I did a cursory survey of students who have accompanied me on Field Schools and found out that there were twenty-three were teaching in South-East Asia, mostly in Japan, in their JET Program, four in Graduate studies and one in law school. At the time I was more interested in how Field Schools have influenced their international perspectives.

My Field School trip to India in 1998 provided me with a cross-cultural experience; a source from which to draw from a continual basis—even years later. From this I can only conclude that Field School has changed my perspectives, and consequently my life experiences.

In India the greeting, with clasped hands, “Namaste”, means I greet the God within. As an addiction counselor I used this manner of greeting as an example of how positive self-talk denotes respect and the giving of the greatest gift—recognition of self and worth. Field School has provided me with a wealth of experiences and knowledge that will continue to benefit me for a very long time to come

--- Donna Holmes. B.A. (Social Worker, Nanaimo, B.C. Canada)

My Field School experience in 1994 was one of my “firsts”. Being a mature student I thought I knew everything I need to know about myself and the world around me. Yet it became apparent, quite quickly, that I had so much to learn. I was back in kindergarten where real transformational learning takes place. Field School may be the first time where one’s values and beliefs are challenged; where one’s global views are significantly altered.

Like my Field School experiences I continue to seek more “firsts”—especially since the completion of my M.A—that would provide opportunities for long term transformational learning which would be both inspirational and challenging.

--- Diny van Beers, B.A., M.A. (Executive Assistant to the President, Malaspina University-College, Nanaimo, B.C., Canada)

My Field School experiences (India 1998; Thailand/Malaysia/Bali 1999; Thailand/Cambodia 2001) have been invaluable, both in terms of life, in Graduate School as well as a practicing attorney. I am able to interact freely with diverse groups of people by sharing common experiences from their home countries. I law school I incorporated my International Field School experiences in my studies. As a Graduate Student (in Anthropology) and a Teaching Assistant I was better prepared to interact with my peers and at the same time share a lot of my field experiences, and excitement, with a new wave of hopeful academics. Today, I bring my Field School experiences into my professional life.

--- Stephen Littley, B.A. M.A., (abd), L.L.B (Attorney at Law, Nanaimo, B.C., Canada)
ABSTRACT
This study was undertaken to examine the knowledge that primary teachers, student teachers and teacher educators have regarding the understanding of language, vocabulary, vernaculars and technicalities in the curriculum and instruction of (Primary) School Mathematics in Fiji. The common assumption that all those who teach and learn primary mathematics are often fluent with the proper language of mathematics is always taken lightly and has become a general belief without reasonable justification. For the purpose of this study, a sample of primary teachers, head teachers and teacher educators in the western part of Fiji was selected. The main research instrument used in this study for the purpose of gathering data included questionnaires, observations and interviews. The theoretical and conceptual basis for this study was drawn from relevant literature from both local and overseas sources. The literature review highlighted the importance of primary mathematics language and its value within the curriculum and daily mathematics instruction. The findings of this study saw most primary teachers and student teacher trainees lacked the understanding of mathematics language. The study revealed that lack of training on the part of the teachers, the heavy workload, and poor teaching approaches and improper languages used lead to the lack of proper mathematics language knowledge. The study concludes with important implications and recommendations for policy makers, primary teachers, head teachers, teacher educators, and curriculum developers to consider strengthening the knowledge base of all concerned regarding the understanding of mathematics language in primary schools around Fiji.

Introduction

Competency on primary mathematical vocabulary is crucial in a primary teacher’s teaching and the learning of children whom they teach. Bushbridge and Womack (1991), suggest that language plays a crucial role in the process of children making sense of mathematics. Bobis, Mulligan, Lowrie & Taplin (1999), states that it is the mathematical language that communicates the ideas, not only to other people, but also to ourselves by helping us refine and clarify them in our minds. The literature by Booker et al., (2004), further states that appropriate mathematical language carries meanings to the role of mathematical materials, symbols and patterns developed in mathematics because materials and symbols by themselves do not literally carry meaning. To enable students to abstract from a number of experiences, the teacher must provide the experiences through the use of language (Sullivan & Clarke, 1991). Teachers must also provide opportunities for those experiences to be recalled and expressed in their own words at what ever level of school students have reached. Teachers therefore ought to understand the language of mathematics to enable them to guide students effectively in a mathematics lesson (Wood, 1990).

Purpose of the study

The purpose of this study was to examine the ways that primary teachers and primary teacher trainees perceive and value the common mathematical language frequently used in Fiji primary schools. A particular emphasis was focused on the roles and perceptions of primary mathematics teachers, primary teacher trainees, primary head teachers, and teacher educators of Lautoka Teachers College (the only government teacher training college in Fiji). Through the study, the researcher gained some ideas of how teachers in both upper and lower primary settings could work collaboratively, to support the effective use of proper mathematical language in the classroom. It is also envisaged that the roles of teacher educators are crucial in shaping the perceptions of mathematics teachers and teacher trainee’s understanding of mathematical terminology and teacher confidence in using primary mathematics languages and vocabularies. Therefore, the study investigated the ability of teachers to handle definitions and explanations of mathematical terminology commonly used in Fiji primary classrooms by providing them with a questionnaire where they could choose correct definitions to assure their understanding of some common mathematical terminologies. The study also used its field data gathered to review the present pre-service teacher training programme at the teachers college and also plan a structured in-service training programme for the teachers college in the future. The study also focused on primary head teachers’ roles in teachers attaining an effective mathematics language understanding and usage in the primary classrooms.
Research Questions

The study attempted to answer the following questions:

1. How good (competent) are our primary school teachers and trainee teachers in understanding the primary mathematics vocabulary, technical terminologies and mathematical language?
2. What are the perceived obstacles to a better understanding of primary mathematics vocabulary, technical terminologies and mathematical language for teachers and teacher trainees?

Education System

This research was positioned in Fiji – a post colonial British economy. The development of education in Fiji had been a subject of a number of education commission and education reports since 1909. These included:


The most recent of these is the *Fiji Education Commission: Learning Together: Directions for Education in Fiji, (2000)* which saw submissions and contributions from individual academics, educational groups, and organizations on the way forward for Fiji’s education. It reported an outcry from education stakeholders, and the public for the immediate addressing of poor achievement in the area of numeracy in primary education, and the government through the Ministry of Education to take a leading role. While most suggested areas for review included the curriculum, and the school children’s ability and backgrounds. Very little has focused on the implementers of the curriculum materials and their training and knowledge.

For this research the sample was chosen according to the location of teachers in both rural and semi-rural areas. A final sample of one hundred (100) primary teachers and a hundred and fifty teacher trainees (150) were selected with which half the sample of primary teachers was from rural remote schools and the other half from semi-rural schools. A sample of nine (9) head teachers was interviewed in the form of a focus group. From the nine (9) head teachers, five (5) were chosen from the remote rural communities and the other four (4) from the semi-rural communities. This was to find out what head teachers in both communities do to support their classroom teachers to improve their teaching of mathematics language in their individual schools. The focus group interview with four teacher educators at the teacher training college was to find out whether or not there was provision for the learning of mathematical terminology within the courses offered to trainee teachers and what possible steps could be taken to address any need in this area.

Languages in Fiji’s schooling system

There are some 300 Fijian dialects, all belonging to one of the two major groupings (Veramo, 1992). Veramo suggests that a language line runs through the islands and divides the Fiji group into a western language group and an Eastern language group. In addition, many of the communalecs, such as those of the western group, are so different from those in the east that they could be considered a different language.

Generally speaking, Fijian, Fijian Hindustani, and English are the official languages of Fiji. English is a mother tongue for minorities, while Fijian, an Austronesian language, is a mother tongue for almost half the population, and is spoken by most Fijians. Fijian Hindustani, an Indo-Iranian language, is the first language for those of Indian descent, who make up just under half the population (Veramo, 1992).

Theoretical Perspectives

Vygotsky, (1986), focused on the importance of socio-cultural dimensions and language as characteristics of formal schooling and learning. His related theory of mediated learning speaks volume about his emphasis on the importance of language in learning (ibid.). This study is no exception. Donaldson, 2000, says language plays an
essential role in the formulation and expression of mathematical ideas. To further support what Donaldson said, Borba (1997), sees language as a tool in the development of thinking as well as a vehicle for the expression of thought. In the South Pacific islands societies, talking enables us to clarify our thoughts as well as to communicate them to others, and adult experience shows that discussions are a very fruitful problem solving technique in most South Pacific island societies including Fiji (Thaman, 1996).

Vygotsky described contexts for development, in social interaction between adults and children and, in particular, the role played by adults in guiding and mediating learning as contexts for learning and development through the use of proper language (Moll, 1990). This approach is of particular relevance to the study and central to this interaction is instruction that develops in children an increasing mastery of the language of learning so that they acquire conscious awareness and voluntary control of knowledge (ibid). To facilitate the development of learning embedded in the everyday world, teachers, students, and peers must interact, share ideas and experiences, solve problems and be interdependent. This interdependence in social context is central to a Vygotskian analysis of instruction (John – Steiner & Mahn 1996., Moll 1990).

According to Clements and Ellerton, (1990), in recent years mathematics education research has begun to take account of how language factors influence learning. There has been a need for a theory to unify and direct discussion and research, and in turn influence, in a positive and practical way, not only mathematics curriculum development, but also teaching and learning in mathematics classrooms. More studies regarding this theoretical underpinning had been done, such as that by Carraher (1988), Lave (1988), McBride (1989), Secada (1988) and Walkerdine (1988), suggested that new theoretical bases are emerging in mathematics education, and that a reconstruction of research methodologies is underway. Some of the ongoing research that has enabled new insight into what goes on in mathematics classrooms have created new discoveries about the all important role of the classroom teacher as the facilitator of classroom activities and games (Gawned, 1990).

Furthermore, Bishop (1988, p.151) raises the need for teachers of mathematics to help learners understand the meaning of mathematical ideas, and argues that this is done by ‘establishing connections between the particular mathematical idea under discussion and the remainder of the individual’s personal knowledge’. Thus according to Bishop, (ibid), a new idea is meaningful only to the extent that it is connected with existing knowledge and, according to Bishop, such connections are made by individuals in response to new and potentially disturbing phenomena in the environment. Teachers who seek to ensure that this phenomenon encompasses their teaching and learning are best called success-based teachers.

This study agrees with Light and Perret-Clermont (1989) in saying that all the theories discussed in this study are more often in practice presently, and at times may overlap into each other while implemented in the classroom during the learning of mathematics. As Clements, (1980) argues, the interface of mathematics and language is ever-present within mathematics setting regardless of which theories are being implemented by the teacher. Competency of teachers in the mathematical language according to Pirie et al., (1988) is crucial to the learning of mathematics because it is through the use of mathematical language in discussions that learners and teachers can come to terms with the mathematical ideas, develop ways of expressing concepts and processes and take on the ways of thinking as their own. Teachers ought to possess the understanding and thorough background knowledge of the concept they are teaching in a topic(ibid: p.14). A topic or unit of work for mathematics in the primary schools may have more than one concept to be dealt with and teachers ought to know them all (ibid.). However, through other studies like Bennet et al, (1984); Bourke (1984); Clark (1984) and Cobb (1988), the reality of everyday mathematics classroom situations has made it difficult for teachers to organise and maintain more open forms of interaction. It is from these theoretical perspectives that this study intends to acquire some directions suggesting that there is no individual knowledge, only that which is commonly instructed by individuals through interactions with tools, language and groups in their cultural context (Pollard, 2001).

Findings and Discussion

The findings of this study is drawn from the 90/150 (60%) gathered feedback from student teachers and the 85/100 (85%) gathered feedbacks from teachers in schools. The analyses of the first 7 questions on the questionnaires for both groups are shown on table 1.0 below.
### Table 1.0 – Summary of Results for (a third) of the Questionnaire Questions.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Concept</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>Incorrect Answers in Total (%)</th>
<th>% of Correct Answers per question</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A Figure 5.1</td>
<td>Algorithm (ST)</td>
<td>10%</td>
<td>19%</td>
<td><strong>Answer</strong></td>
<td>9%</td>
<td>21%</td>
<td>59%</td>
<td>41%</td>
</tr>
<tr>
<td>1B Figure 5.2</td>
<td>Algorithm (T)</td>
<td>11%</td>
<td>14%</td>
<td>answer</td>
<td>10%</td>
<td>9%</td>
<td>44%</td>
<td>66%</td>
</tr>
<tr>
<td>2A Figure 5.3</td>
<td>Area(ST)</td>
<td>answer</td>
<td>44%</td>
<td>8%</td>
<td>2%</td>
<td>25%</td>
<td>79%</td>
<td>21%</td>
</tr>
<tr>
<td>2B Figure 5.4</td>
<td>Area (T)</td>
<td>answer</td>
<td>27%</td>
<td>6%</td>
<td>7%</td>
<td>22%</td>
<td>62%</td>
<td>38%</td>
</tr>
<tr>
<td>3A Figure 5.5</td>
<td>Number System Base(ST)</td>
<td>28%</td>
<td>22%</td>
<td>answer</td>
<td>11%</td>
<td>21%</td>
<td>82%</td>
<td>18%</td>
</tr>
<tr>
<td>3B Figure 5.6</td>
<td>Number System Base(T)</td>
<td>3%</td>
<td>16%</td>
<td>answer</td>
<td>13%</td>
<td>22%</td>
<td>54%</td>
<td>46%</td>
</tr>
<tr>
<td>4A Figure 5.7</td>
<td>Bisecting lines(ST)</td>
<td>13%</td>
<td>answer</td>
<td>17%</td>
<td>32%</td>
<td>28%</td>
<td>90%</td>
<td>10%</td>
</tr>
<tr>
<td>4B Figure 5.8</td>
<td>Bisecting lines(T)</td>
<td>9%</td>
<td>answer</td>
<td>13%</td>
<td>23%</td>
<td>22%</td>
<td>67%</td>
<td>33%</td>
</tr>
<tr>
<td>5A Figure 5.9</td>
<td>Capacity(ST)</td>
<td>24%</td>
<td>31%</td>
<td>answer</td>
<td>0</td>
<td>30%</td>
<td>85%</td>
<td>15%</td>
</tr>
<tr>
<td>5B Figure 5.10</td>
<td>Capacity(T)</td>
<td>21%</td>
<td>11%</td>
<td>answer</td>
<td>31%</td>
<td>6%</td>
<td>69%</td>
<td>31%</td>
</tr>
<tr>
<td>6A Figure 5.11</td>
<td>Circumference(ST)</td>
<td>0</td>
<td>answer</td>
<td>34%</td>
<td>12%</td>
<td>13%</td>
<td>59%</td>
<td>41%</td>
</tr>
<tr>
<td>6B Figure 5.12</td>
<td>Circumference(T)</td>
<td>0</td>
<td>answer</td>
<td>22%</td>
<td>2%</td>
<td>23%</td>
<td>47%</td>
<td>53%</td>
</tr>
<tr>
<td>7A Figure 5.13</td>
<td>Congruent Shapes(ST)</td>
<td><strong>Answer</strong></td>
<td>47%</td>
<td>14%</td>
<td>6%</td>
<td>3%</td>
<td>70%</td>
<td>30%</td>
</tr>
<tr>
<td>7B Figure 5.14</td>
<td>Congruent Shapes(T)</td>
<td><strong>Answer</strong></td>
<td>38%</td>
<td>17%</td>
<td>5%</td>
<td>14%</td>
<td>74%</td>
<td>26%</td>
</tr>
</tbody>
</table>

[ST – Student Teachers  and  T – Primary Teachers]

The above summary table provides only the first 1/3 of the original Questionnaire findings. The responses (%) for each options A – E are shown with the correct responses (%) highlighted. The “A” questions are responses from student teachers, while the “B” ones were from teachers teaching in primary schools.

During the interview with the focus groups, competence with current primary mathematical vocabulary was mentioned as a necessary requirement for all teachers who teach mathematics in the primary schools and is seen to be of vital importance. The importance of being competent in mathematical language in mathematics were perceived and broken down into three major themes according to the survey questionnaires and the focus group interviews. Just a third of the questionnaire results are provided on page 6 in Table 1.0, for discussion, which clearly shows a very high percentage of incorrect responses from both student teachers and primary teachers who were participants to this study.

It is important being competent, with specific mathematical terminology that only generates meaning within mathematical context such as the following words; ‘Algorithm’, ‘Area’, ‘Fraction’, ‘diagonal’, ‘circumference’, ‘perimeter’, ‘polygon’ and ‘product’ A few student teachers and primary teachers identified correct responses regarding the above mentioned mathematical terms, what is quite alarming is the high percentage of student teachers and primary teachers that opted for the incorrect option and those that simply admitted that they did not know (option E).
For ‘Algorithm’ for instance, only 41% of student teacher participants as shown on table 1.0, figure 5.1 chose the correct option and it is alarming to note that (39%) could not identify the correct meaning of algorithm. The second common mathematical terminology appeared in question 2 which is the word ‘Area’. The data presented in figures 5.3 and figure 5.4 [page 6] showed the responses gathered from student teachers and the primary teachers. Again a large number of student teachers (79%) made wrong choices choosing either option B, C, D or E. Only 21% made the correct choice on option A. For primary teachers, on the same question, only 38% of the participants chose the correct option A and 62% primary teachers did not get the correct response. The similar trend shown in the incorrect percentage responses sample provided says a lot about the poor understanding of mathematical language from both groups of participants in this survey.

When teachers lack specific mathematical language required to teach mathematics, they can opt for substitution word or phrases in class. A good example is when teachers refer to ‘answers’ instead of products and sum in situations like [7 x 2 = or 3 + 4 =]. The teacher usually uses the question “What is the answer”? Instead of “What is the product”? Proper language use when taken lightly can only bring more difficulties in the learning and understanding of mathematical terminologies. This study has showed that most qualified teachers and student teachers lack the basic understanding of proper mathematical language required to teach mathematical concepts effectively in their classrooms.

Teachers in rural schools as was raised by the head teachers in one of the interviews lacked access to good resources and other support materials to assist them in the lesson preparation. The only basic resource they had included the teacher’s guide and pupil’s book. Moreover, resources need to be made available in rural schools so that teachers can benefit from them in their day to day teaching is also an important point to consider. In the first theme, most words that were introduced are basic mathematical terminology that any teacher ought to have known. Unfortunately, this study has shown that this general assumption that [teachers are competent with all mathematical words], we often make, is an unrealistic one.

According to Walden and Walkerdine (1985), this lack of knowledge could have been caused by simply a lack of knowledge about the word itself. It could be said that both student teachers and primary teachers who could not define ‘algorithm’ or any of those other words mentioned so far, correctly, lacked the relevant information within their ‘knowledge bank’ due to lack of information access in the form of reading through mathematical journals, textbooks, pre service training and other important materials that could have enlightened them on the meaning or definition of the word ‘algorithm’. From the head teachers perspective [through interview], it is the lack of vital resources that causes most difficulty for teachers in lesson planning, or unit planning in rural schools. This general trend on poor resources in the rural schools has been a common issue for teachers who teach in rural areas and this could result in the limited knowledge that teachers have.

Furthermore, it could also be argued that the 59% of student teachers and 44 % of primary teachers whom failed to identify the correct option on ‘algorithm’ also suffered lack of exposure to this word through lack of discussion or interaction, on class activities and little or no use at all of mathematical words during pre-service classes. According to Donaldson (1993), modelling as well as usage of terminology and symbols correctly in the context allows for both teachers and students to gain better and lasting understanding of mathematical terms. Results that have come out of this study shows that even most primary teachers, who teach mathematics everyday, are not familiar with the mathematical words that they should have understood.

Wishart, (1977), also argued that mathematical vocabulary ought to be developed contextually to enhance students and teachers’ better understanding of the new words they encounter in a particular unit of work. More frequent reference to these words, during oral communication in class leads to better understanding of most new mathematical vocabulary. Moreover, Earp and Tanner, (1980), and Nicholson, (1989) show that once pupils and teachers have understood and built up vocabulary items at an early stage in mathematics, during their teaching and learning process, existing words always provide necessary meaningful illustrations that can allow pupils to draw correct meaning from.

This study has shown that mathematics language plays a vital role in the delivery of the mathematics curriculum and teachers and students need to familiarise themselves with the language of mathematics to enhance effective and efficient curriculum implementation in the primary classrooms today (Bakalevu,1994). These results gathered from
the questionnaire together with the outcomes of the focus group interviews enable the researcher to make recommendations and highlight a few implications.

**Recommendations**

The data gathered in this study indicated that there is an immediate need for teachers and student teachers to improve on their competency levels in the mathematical language and the commonly used terminologies. Moreover, the sections below also look at some other important recommendations, and have proposed that certain actions be taken immediately. The recommendations are aimed at the following:

**Primary School Teachers**

From the evidence gathered in this study, there needs to be better methods of planning and teaching mathematical language to students since language, as Pollard (2001), argues holds the very medium required to express teachers and children’s thought in mathematics in a classroom. This study showed that primary teachers themselves should be supported to adhere/adopt to the following:

- Ensure they possess a reasonable supply of mathematical teaching materials.
- Ensure that they broaden their mathematical conceptual understanding through journal & book reading, internet exploration, and participation in mathematics workshops or short courses.
- Utilize teacher – student communication more in the classroom and take a constructivist approach to their teaching mathematics.
- Continuously use proper mathematics language more than Ordinary English in their day to day teaching of mathematics.
- Make it a professional behavior to consult their peers on aspects of mathematical terminology before teaching their class.
- Actively engage themselves into enrolling in distance studies so as to upgrade their qualifications while teaching in the field.

**Student Teachers**

It was evident from the focus group interview with teacher educators and the data gathered from student teachers responses that a good percentage of student teachers were also incompetent with basic common mathematical terminology. For student teachers to improve their knowledge in mathematical language in the future they would need to do the following:

- Actively participate in all mathematics workshops provided at the college during the two years of their training.
- Familiarize themselves with the words commonly used in primary mathematics teaching and understand their meanings.
- During their teaching practice participate in more interactive collaborative sessions doing mathematics through activity-based approach and opening their classes to more discussions.
- Develop a primary mathematics lexicon (book) where they can enter all mathematical language with specific meanings and also the vernaculars in their mother tongue where possible during their two years of training.

**Head Teachers**

The head teachers’ role was identified as a very important one as far as curriculum implementation and monitoring processes were concerned. The results from this study recommend the following:

- That all head teachers engage in effective curriculum implementation and monitoring at their school level.
- That all H/Ts ensure provision and readiness of teaching materials and facilities in schools at all times.
- That all H/Ts, in consultation with the local school committees, ensure that the school operates on a healthy financial status throughout the year.
- That all H/Ts closely monitor staff and student performance in their schools.
- That all H/Ts ensure that all staff members in the school undergo some form of staff professional development or distance studies.
- That all H/Ts, in consultation with the local school committee, ensure that all staff members are provided a chance to get a transfer to another school at the end of his/her fourth year.
Teacher Educators
For teacher educators, this study recommends the following

- All mathematics education assessment tasks are reviewed and the making of a mathematical lexicon be included as an assessment task
- All teacher trainees (new intake) attempt to answer the questionnaire used in this study in the very first week after enrolment and also on the final day of lectures at the end of their second year.
- All assessment tasks that are utilizing seminar presentation be changed to micro-teaching tasks to give trainees more chances of polishing-up their practice at college.
- Lecturers see that they read widely on current mathematics journals and information from the internet and ensure to engage themselves in some sort of distance studies in their curriculum areas.

National Policy
The following recommendations have been made in regards to the national policy of the Ministry of Education:

- Policies regarding teacher training and teacher upgrading be redesigned to include a continuous programme for teacher in-service for those who have spent many years in the field.
- Policies addressing upgrading of teacher educators at the tertiary level be reviewed and better human-like incentives created.
- Salary levels of teachers be reviewed and upgraded to meet the realistic cost of daily living
- A thorough review of our present performance based assessment carried out to all classroom teachers and also the manner in which our Annual Confidential Reports are assessed and filled at school levels.

Implications
The implication of these findings places the call for redress in the learning of mathematical language in areas such as:

Role of the Ministry of Education
The Ministry of Education’s role has been sound and classic on paper. What needs to be reviewed are the implementation processes of proposed developments that has looked very promising during the planning stages. One of the most common roles of the Ministry of Education is to write education policies. Whether a term for review has been tagged and followed through on every policy documented or not is an area of concern for every tax-payer and education stakeholders in Fiji. As always, the Ministry of Education’s lack of funding for such reviews and upgrading of policies remains as an ‘eye sore’ for those who know the system well.

Partnership with Parents
Partnership is needed as it plays a major role in the betterment/improvement of student’s work. The support and the involvement of parents and families are vital for successful learning of mathematical language in primary schools. Mathematics is a practical subject that requires more and more practice. There ought to be provisions at home for students to be able to do mathematical activities and also solve more exercises from pupil’s texts that are always meant for more practice. In general parents have a role to see that students are sent to school on time, fed well, provided with all their basic school stationary, encouraged daily and their work progress monitored constantly. Overall this leads to more community involvement in education and can lead to better and healthier relationship for all stakeholders of education.

Teacher Training
Pre-service primary teacher training should focus components of their mathematics education courses towards successful learning of mathematical language in primary schools. In the review of literature in this study, many theorists have raised the importance of learning mathematical language as suggested in the primary mathematics texts and teachers’ guides. Trainee teachers need to be taught the appropriate skills and pedagogies of effective mathematical language teaching, so they are familiar with the approaches when they are in the field.

Conclusions
The findings of this study confirm that Fiji head teachers and teacher educators need to do more to upgrade and broaden the teachers and student teachers’ mathematical vocabularies, and associated terminologies. Findings of this small-scale research have important consequences for the learning environment in all primary mathematics grades in Fiji and teacher in-service provisions at tertiary level. The obstacles to better mathematical language understanding
that have been raised by head teachers are issues to be dealt with seriously by the Ministry of Education officials and Education Officers. In our primary schools, this study has not been able to determine whether teachers are implementing mathematics curriculum effectively or not. But if the revealed knowledge and understanding of teachers and student teachers, gathered in this study are things to consider, then there is a greater goal to be accomplished in this area to ensure primary mathematics language usage and mathematics talk in the classroom is not compromised by teachers of mathematics in our primary classrooms.

REFERENCES


REFLECTIONS ON THE DEVELOPMENT OF A WEB-BASED COURSE TO SUPPORT EFL LEARNING FOR PRE-SERVICE TEACHERS IN THAI RAJABHAT UNIVERSITY: A CASE STUDY

Vijittra Vonganusith
Sakon Nakhon Rajabhat University, Thailand

Dr Jeremy Pagram
Edith Cowan University, Australia

ABSTRACT

In a modern, information rich, economically driven society, Western universities as well as Thai Universities are turning towards the Web to disseminate and retrieve information. Integration of computers to support the learning environment in teaching language is still in its infancy in Thailand. Its implementation changes both the instructional strategy and also the teaching and learning environment. This paper examines how a web-based course was used as a tool to support English as a Foreign Language (EFL) teaching and learning for pre-service teachers at a Rajabhat University in Thailand.

Keywords: Evaluation of a web-based course, Pedagogical strategy, Applications in EFL teaching and learning, Interactive EFL learning environment,

INTRODUCTION

This paper is based upon part of the work that forms a much larger doctoral study. It describes the development and evaluation of a pilot web-based course that was developed to be used as a tool to support English as a Foreign Language (EFL) teaching and learning for pre-service teachers in Rajabhat universities in Thailand. It is hoped that further development of this course will lead to a web-based English language training system that will provide an enhanced preparation pre-service teachers for learning effective language and computer skills.

As in all modern, information rich, economically driven societies, Thai Universities are turning towards ICT to disseminate and retrieve information (Bash, 2005; Chansilp, 2003; Neo, 2004; Shannon & Doube, 2004; Thongprasert, 2003). This includes the integration of computers into language teaching to support the language learning environment as an instructional strategy (Lo, Wang, & Yeh, 2004; Neo, 2004; Souza & Fardon, 2002; Tse-Kian, 2003; Wattanaboot, 2003). Thus the traditional teacher-centred method of teaching has been modified and enhanced. The challenge is how to best facilitate effective teaching and learning as well as restructure curriculum to meet the rising demands of the knowledge based society that Thailand aims to become (Hepp, Hinoestroza, & Laval, 2004, p. 299; Ministry of Education, 2007; ONEC, 1999; Ping, Swe, Hew, Wong, & Shanti, 2003; UNESCO, 2006).

Rajabhat Universities located around the country, are well positioned to cater to the educational requirements of a wide section of the population. One of the underlying philosophy of Rajabhat Universities is not only to promote the academic and professional status of teachers and educational personnel but also to apply advanced technologies to enhance instruction and improve efficiency. Until recently pre-service teachers in Rajabhat have had limited and basic computer experience. This experience has often been limited to performing fundamental tasks such as word processing (Wattanaboot, 2003). As many university students are now quite familiar with new technology, especially computer usage, it is appropriate that computer-based learning environments become practical in their application. Much research has shown that learners need to have “both a concrete and abstract knowledge of computers and need to be able to apply their knowledge to new systems and new situations with minimum retraining” (Winter, Chudoba, & Gutek, 1997). Thus, the needs of the university are to provide online courses that serve differing pedagogical approaches.

BACKGROUND

In order to evaluate the development of the pilot web-based course that was designed to support EFL teaching and to evaluate its effectiveness, questionnaires were administered to experts and educators who had reviewed the course. The data obtained from responses concerning attributes of engagement and attraction were analysed. Questions (Likert scale based) sought the viewers’ opinions and impressions towards the interface and content. The results are to help develop the online course.
DESIGN OF THE PILOT COURSE

The pilot web-based course was intended not to be a separate system but more a “portal” into the university’s network. Thus the course contains background information from the university’s existing computer-based environment. These include FAQs, basic computer knowledge, lesson plans, and step-by-step self-interactive computer-based lessons. These link up existing information structures, and so generate savings in the time and cost of information production. The information provided was designed to be relevant to university students and teachers of EFL, and also provides for easier accessibility for students both on and off campus. The course attempted to engage the students’ interest by organizing and presenting the information in real-life situations. The interface and contents are designed to be easily to use. The course intends to be fun and easy by not involving lengthy instruction without interaction. It also provides information via audiovisual means using the image and voice of a native speaker to help gain listening competence. Social activities and other interactive information helps encourage more collaboration and cooperation at a recreational level. The graphic style and content used was targeted towards the age group (18-23 years old), as much as possible by using both in colour and content.

Figure 1: A flowchart of the web-based course

The web-based course was designed for easy navigation, as shown in the flowchart (Figure 1). The first level entry layout accesses the entire web-based course (A) as well as a Frequently Asked Questions (FAQ) section (B) that gives access to any relevant information (C). The third level (D, E, and F) links to existing information in the computer-based learning environment course. The initial item encountered on the computer-based learning course is a log in with a soundtrack to gain the attention of the users; vibrant colours are employed to attract attention (Figure 2).
Figure 2: Screen shots of the Flash animated introduction sequence

The main menu screen (Figure 3) uses pictorial links to various sections of the course (A).

Figure 3: Screen of a main menu (level 2)

There is “one-click” access to other sections available from a navigation bar at the top of each screen (Figure 3). Navigation bars are located at the top of each computer-based lesson environment course screen. The FAQ section (B) links to Course main menu (A) as well as University Main menu provides access to the main streams of information and is presented in a non-linear format (Figure 4). The information is divided into the framework of “who, why, what, where, when and how”. The contextual links are provided to navigate to appropriate content on the main menu. The users are also allowed to post and share their experiences and/or problems or other relevant information. These sections are provided to be available when needed to provide answers to questions, or to offer further contact advice. A further aim of these sections is to support communication within the learning community.
The users access the 'Introduction to basic computer' section (D) to gain support with basic computer skills. The users then have a chance to learn how to navigate through audiovisual materials and content (Figure 5).

Figure 5: The introduction to computer section

The following section is shown when you click on the Lesson Plan of computer-based learning environment course on Course Main menu (Level 2).

Figure 6: The lesson plan section
Part of the intended EFL training methodology was to use a computer Authoring environment to allow the acquisition of English language skills within a realistic context. The environment chosen was Authorware, chosen because of its both language and iconic driven interface and its availability within many Rajabhat universities. Its intended application within the EFL training classroom is described below.

- The first week pre-service teachers will be informed about general basic computer use, including keyboards and general computer technical terms. Authorware function keys will also be presented.
- They will be allowed to practice using different function keys of Authorware step by step.
- The second week pre-service teachers will retrieve the chosen contents of prepositions of place, location, date and time. The storyboard will be written and share among group and pair work. The instructor and peers will give comments and feedback.
- The third week pre-service teachers will create and present their own work. They are allowed to observe and consulted their peers or instructor anytime.
- The final week, pre-service teachers will present their work and give comments and feedback about their peers’ work. Then they will edit their work and package it onto a CD-ROM.

Figure 7: The section of step by step constructing the users’ own interactive EFL lessons using authoring software

Within a mouse click on the highlighted area (G) accesses to information about using authoring software (G). The audiovisual will inform how to use authoring software step by step (Figure 7). Within one click on Interactive computer-based Lessons (F) providing in grammatical section e.g. prepositions, the students learns and practising the sample of grammar structure concerning prepositions (Figure 8).
EVALUATION METHODOLOGY

Instruments

In order to formally evaluate the pilot course a set of internationally recognised software evaluation tools developed by Professor Thomas Reeves were used. Reeves’ evaluation tools provide 20 criteria or pedagogical dimensions for evaluating the educational aspects of any software. The criteria include; the design of the interface, pedagogy philosophy and psychological theory, instructional sequencing, the role of errors and the teacher/trainer, learner control, and cooperative learning (Reeves, 1997). In addition, Bates (2000) believes that seven factors need to be considered in evaluating the effectiveness of different instructional technologies: online course access and flexibility; cost; teaching and learning; interactivity and user friendliness; organisational issues; novelty; and speed. Further evaluation criteria relevant to courses and programs delivered in the World Wide Web. The considerations include class size, synchronous and asynchronous activities, instructor response time, ease of navigation, and opportunities to interact with peers and the instructor (Cyrs, 2001). In addition, a checklist of critical elements characterising effective learning environment in three man categories are offered to evaluate online course: (1) Pedagogies, the learning activities which underpin the unit; (2) Resources, the content and information which are provided for the learner; and (3) Delivery strategies, is associated with the ways in which the course is delivered to the learners (Herrington, Herrington, Oliver, & Willis, 2001). The evaluation strategy takes all of the above into account in providing recommendations for further development of the course.

Participants

The pilot evaluation participants were three educators having experiences related to computer-based courseware design. The participants were administered to reflect on the course and examine whether the web-based course is useful for EFL teaching and learning.

Reflections

In this paper, the results from the questionnaire based on Reeves’ Interface and Pedagogical Dimensions will be discussed along with the overall conclusions from the evaluation process. In the Reeves’ evaluation process, participants rated each criterion on a 5-point Likert scale from Strongly Disagree (1) to Strongly Agree (5). A rating identified the participants’ opinion of the designed web-based course. The overall summary of these findings is discussed below.
Interface Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Difficult</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Easy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Navigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difficult</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Easy</td>
</tr>
<tr>
<td>Cognitive Load</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unmanageable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Manageable</td>
</tr>
<tr>
<td>Mapping</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Violates Principles</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Powerful</td>
</tr>
<tr>
<td>Screen Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obtuse</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information Presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clear</td>
</tr>
<tr>
<td>Media Integration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordinated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aesthetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pleasing</td>
</tr>
</tbody>
</table>

Figure 9: Interface design dimensions

- This web-based course is easy to use as there are no complicated functions or navigation (M=5). The participants found that it is a strong feature of this website. The links and formats support beginners as well as advanced users.
- Navigation is linear so it is extremely easy to operate and know where the user is in the program and how to go to another section (M=5). The navigators appear on fixed areas on the screen.
- The information seems to be easily accessible. Some physical activities provided on the quizzes can be handled by the mouse pointer. The cognitive load of this website seems easily manageable. The mean score (M=3) is ranked as medium.
- The web-based course provides a mapping system to track the information the user has accessed or interacted with. This website is given the highest mean score for its powerful mapping function (M=5).
- Icons, graphics, colour and other visual designed in this web-based course are ranked with the highest score (M=5). The light green background of the screen is comfortable to the eyes. The animation provided in each page is enough to engage the intended audience.
- Information in the web-based course is presented in a comprehensible form (M=5). The hyperlinks help the user learn and understand the information. The language used is simple for intended users. Some hyperlinks provided help to trace related information.
- There is adequate media integration throughout the designed web. From the highest rated mean score (M=5) given it can be assumed that an audiovisual integral helps to attract and engage the intended learners.
- The aesthetics is pleasing (M=4). This web-based course is useful for teaching and learning how to construct an interactive English lesson. It is ranked in the highest mean score related to the target audience. However, the contents should be adjusted to suit EFL learners. For example, there could be some translations included to assist non-native speakers.

Pedagogical Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Instructivist</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Constructivist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedagogical Philosophy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behaviour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Cognitive</td>
</tr>
</tbody>
</table>

549
Figure 10: Pedagogical dimensions

- This web-based course attempts to present comprehensive knowledge using a constructivist approach (M=4). In the interactive sections, for example, quizzes containing prompt feedback can be seen involving individual motivation, experience, and learning styles to construct knowledge.
- Social interaction with others via discussion board also supports a cognitive development which is one of the key principles of constructivism. This web-based course allows learners to handle their learning themselves. ‘Learning by doing’ is central to constructivism in practice as well (M=5).
- A degree of the goal orientation is ranked to unfocused type (M=4), as the web-based course is likely to encourage learners’ creative thinking, lifelong learning, and to support positive learning environment.
- An experiential value of the web-based course is ranked to concrete type (M=4). The web-based course tends to provide interactive learning environment which fosters learners’ abilities to retrieve, assimilate, solve, and construct knowledge, skills and attitudes into relevant situations.
- The underlying psychology falls into behaviour learning theory and cognitive learning theory and constructivism (M=4). This web-based course supports behaviour learning theory in terms of responses, feedback and reinforcement. The website acts as a tutor presenting information. The user, then, is set to respond to questions provided at the end of a section. In addition, the set criteria will evaluate the user’s responses. The learner also has multiple opportunities to practise and provide the correct answer.
- Limited teachers’ and trainers’ direction is required in this web-based course (M=5). However, if included in a classroom setting, it would provide cooperative learning or collaborative learning strategies with appropriate teacher guidance. Participants comment that some translation should be provided for EFL learners.
- The web-based course allows learners to learn from their experience on the ‘wrong’ trial in quizzes’ section (M=5). The learners may click on the responses randomly and feedback will be provided at the end of the quiz. This process encourages the user by providing a challenge to find the correct response.
- This web-based course allows learners’ freedom to direct their required contents by simple navigation (M=5). Contexts are useful and informative. The animations and audiovisual effects could contribute towards making the lessons more interesting, which in turn could assist in maintaining individual motivation and engagement.
- This web-based course fosters individual differences as the accessibility allows learners to achieve their own goal supporting different learning styles (M=5). This web site rates the highest mean score constructing, elaborating, and representing knowledge.
Participants in this study rank the web-based course to most unrestricted learner control (M=5). The learning practices encourage learners’ control in managing the information retrieved and discussed to work independently. For example, learners are required to adopt appropriate animations, font, colours and language use and examples to suit their projects. In other words, this learning environment is likely to allow learner to explore different contents, sections or learning activities through interactive materials.

- Participants view that the when measuring potential accommodation of individual differences.
- The user activity is ranked to a generative type (M=4). Participants agree that the learning activities on the web-based course tend to maximise opportunities for discovery. Learners also engage in a learning process of creating, web-based course tend to support cooperative learning environment (M=5). Group work and pair work is utilised to initially share contents created through the sharing of storyboards and contents. In addition, learners could choose to consult texts, other students and teachers, or peers via the internet.

CONCLUSIONS

While based on the ratings given, participants perceived the online learning system to be an effective instructional web-course; the development and evaluation process did reveal some issues that need to be taken into account in the design of the full online version. Some of these issues relate to access, to design and others to learning styles. Thailand has great variations of ICT and online access this means that students using any online learning system often have great variations in ICT skill levels. Also as bandwidth and internet access for students is very variable beyond campus boundaries the online course may only be effective when used on campus. Accommodating this diverse range of learners is imperative as courses move online. The researchers feel that with the move to online learning we have gained an incredible ability to give students a new way of learning that is very flexible but the use of such system still requires access to human teacher who can adapt to their students’ needs. Thus the prototype has revealed the need to design the pedagogy as a complete system that includes the learner, the teacher, learner environment and the online learning system.

It is hoped that by understanding the limitations of the current system, the designer can make the best use of limited resources available when advising upon the development of the full system, without alienating students or shutting them out by the use of resources too media rich to be viewed on the computers available. The materials can then be designed around the learners needs, rather than round the needs and limitations of the technology.

REFERENCES


ABSTRACT

Peer review processes are useful as media for learning and communicating as well as for maintaining the standard of a paper being reviewed. Conferences that intend to publish printed proceedings always call for peer review processes before the paper is accepted for publication. The author(s) –especially beginner(s) - may learn from the feedback provided by the reviewer(s); and at the same time the review process functions as a medium of exchange for the research/study being done. This paper reports the processes of blind peer review that were applied in a recent conference. A total of 69 papers with no author names were sent to reviewer panels. Every paper was sent to two reviewers. After the reviewers’ names were removed the papers were sent to the author(s) for necessary action. The authors’ written comments on the feedback were sought through email. This study found that most of the reviewers provided adequate and useful feedback. However, this study also documented that some reviewers did not properly execute their jobs. Positive comments from the authors were noted. This study suggests that a firm and clear guideline for reviewing should be provided. The reviewer should offer balanced comments and critiques on both the strength and weaknesses of the paper being reviewed; and provide alternative suggestions where possible.

INTRODUCTION

Peer review

Whether it appears in print, a combination of print and electronic forms, or only in electronic form, a peer reviewed journal is one in which each feature article has been examined before it is published by people with credentials in the article's field of study.

Peer review processes are useful as media for learning and communicating as well as maintaining the standard of the papers being reviewed. Conferences that intend to publish printed proceedings always call for peer review processes before the paper is accepted for publication. The author(s) –especially beginner(s) - may learn from the feedback provided by the reviewer(s); and at the same time the review process functions as a medium of exchange for the research/study being done.

Collections of papers from conferences may be considered peer reviewed as well, if the original presentations were “invited” or examined by experts before being accepted. Papers that appear in sources like these are considered to be as reliable as humanly possible.

The peer review process is a commonly-used practice by which scholarly work can be reviewed and evaluated by experts who ensure that it meets the expectation of the field or discipline. There are many variants on the methods by which peer review is carried out; however, the basic tenant of the process is present in these various applications. In most cases work, or proposals for work, are submitted to some type of agency, organization, or publisher. The agency or organization solicits reviewers from a pool of experts within a given field and matches the review tasks with reviewers who have expertise in relevant disciplines. Depending on the process, reviewers are provided guidance on how to review the work. The reviewers return their judgments to the agency or organization and this information is used to make decision about the work or proposal. Finally the authors are informed of the decision and any comments or recommendations from the reviewers. This can be a blind process (reviewer’s identity is not disclosed) a double blind process (reviewer and authors’ identities are not disclosed) or one that contains full disclosure (both author and reviewers’ identities are revealed). As educational researchers, the process of peer review is a very common practice and anyone reading this paper has likely participated in this process in at least one form or another. Peer review is used in journal publication for reviewing manuscripts; in professional conferences for reviewing paper proposals, and in contract and grant work for reviewing project proposals.
THE REVIEW PROCESS

As briefly described above the peer review process may consist of several different types of review, namely, open, blind, and double blind, each with its own benefits and shortcoming.

Open review

An open review process identifies the reviewer to the authors and vice versa; the reviewers want the authors to know their identity and may encourage further discussion. Moreover, reviewers may want their names to appear on the review so they can receive credits for their comments. One concern with this kind of review is that the reviewers may be biased based on their previous positive or negative experiences with the authors, or anyone associated with the research. On the other hand, authors may also become vengeful toward the reviewer, thereby influencing their review of a future paper by one or more reviewers.

Blind review

Blind review identifies the authors to the reviewers but not vice versa. Potential reviewers receive the title page of the paper-complete with the full author and institute list-plus the paper’s abstract. Reviewers can then decide whether they would be appropriate candidates to review the manuscript based on the topic and their relationship with the authors. In this type of review, all reviewer information is removed before forwarding review and correspondence to the authors.

Double-blind review

Many journals use a stringent ‘double-blind’ review procedure, in which neither reviewers nor author(s) are informed of each other’s identity. Double-blind review is based on the principle that criticism is more impartial when authors’ identities are unknown to the reviewers who might be affected in either positive or negative directions by the authors’ reputations and personality traits (Kassirer & Campion, 1994). Double-blind review conceals the identities of the reviewers and the authors. This method attempts to ensure that the reviewers are influenced solely by the content of the manuscript and are protected from author biases. However, the quality of the review may suffer because reviewers accept only limited responsibility for their comments – since only the editor can identify them. Moreover, some editors are uncomfortable withholding author information from reviewers, since such knowledge can help reviewers analyse a paper when they are familiar with the work. Last but not least, authors and reviewers both commonly cite their own previous publications, making it possible to guess their identities and removing some of the benefits of anonymity.

Studies on peer review

As a research topic, peer review has been studied, applauded, and critiqued (Harris, Gao, & Welch, 2002; Jefferson, Wanger, & Davidoff, 2002; Kassirer & Campion, 1994; Weber, Katz, Waecckerle, & Callaham, 2002). Rothwell and Martyn (2000) found that in journal publication, the agreement among the two reviewers (on two factors – acceptance and priority of publication) for a series of manuscripts was not better than what was expected by chance. Although rater variability is expected, such differences are important to consider as most editors, conferences program chairs, or funding organizations, will likely report relying heavily on peer review recommendations when making decisions regarding publications, presentation proposal, or project funding.

The results from a randomized experiment conducted at the American Economic Review on the effects of double-blind versus single-blind peer reviewing on acceptance rates and referee ratings indicate that acceptance rates are lower and referees are more critical when the reviewer is unaware of the author’s identity. These patterns are not significantly different between female and male authors. Authors at top-ranked universities and at colleges and low-ranked university are largely unaffected by the different reviewing practices, but authors at near-top-ranked universities and at nonacademic institutions have lower acceptance rates under double-blind reviewing (Blank, 1991).

Nevertheless, we believed that a peer review process is still useful and offers benefits for maintaining the quality of papers to be published in the proceedings and to the authors’ learning as well. Based on this premise we applied a double-blind review to the papers submitted for publication in our conference proceedings.
AIMS OF THIS PAPER

The Second Conference on Science and Mathematics Education (CoSMEd) was held in Penang from 13 to 16 November 2007. The conference was internationally attended by about 200 participants coming from Southeast Asian countries and other countries around the globe, such as Africa, Australia, India, Japan, Seychelles, Taiwan, UK and USA. A total of 89 papers and nine posters were presented in parallel sessions. Fifteen workshops were also conducted during the Conference. Among 89 papers being presented in the Conference, only 69 papers were submitted by the authors for peer reviewing processes. The purpose of this paper are to share and describe our experiences on the peer review processes on the papers submitted for presentation and publication in the CoSMEd 2007 proceedings.

OUR PEER REVIEW PROCESSES

We applied double-blind review process in our conference. There are three coordinators of the reviewer panels who coordinated the review processes between the reviewers and the conferences committee. All papers submitted to the committee were coded, and the authors’ names were removed before sending to the reviewers. The coded papers and the full papers refereeing response form (see appendix A) were sent to the coordinators to be distributed to the reviewers’ panels. The reviewers sent back their comments and recommendations to the coordinators. The coordinators pooled the reviewers’ results and sent them to the committee. The committee classified the review results, removed the reviewers’ names and send to the authors for necessary action. Figure 1 shows the flow chart of the review process.

![Figure 1. The peer review process.](image)

DATA COLLECTION AND ANALYSIS

The data were taken from reviewers’ feedback and comments. Reviewer comments and feedback received were classified and analyzed into three categories, namely: (1) A1: Accepted for publication in the Conference proceedings without correction or with minor correction which were completed by the editor; (2) A2: Accepted for publication in the Conference Proceedings with minor corrections. The authors need to revise the papers as suggested by the reviewers and send back to the committee within one week; (3) A3: Not accepted for publication in the Conference Proceedings but accepted for presentation at the Conference; and (4) A4: Not accepted for publication nor presentation. The results are presented in Table 1.
In addition, an open ended short survey was sent via email to the authors to seek their comments and opinion on
the peer review processes being conducted and their suggestion for peer review in the future Conference. There were
three question posted to the authors:

1. How do you rate the paper review processes: (1) not useful; (2) useful; (3) very
   useful
2. Do you think that both reviewers provide adequate comments, balance critique
   and suggestions on your paper?
3. Please provide your comments so that we can improve our paper reviewing for
   next CoSMEd in 2009.

FINDINGS AND DISCUSSION

Paper review results.

A total of 69 papers were submitted to the Conference committee for the peer review process. The peer review
processes took time approximately four to six weeks to complete. Each reviewer was given a period of four weeks to
review a paper, and authors were given two weeks each for necessary action. The paper review results are
summarized in Table 1.

Table 1

<table>
<thead>
<tr>
<th>Area</th>
<th>Results</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A1</td>
<td>A2</td>
</tr>
<tr>
<td>Science education</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>Mathematics education</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>Technology education</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
<td>27</td>
</tr>
</tbody>
</table>

A1: Accepted for publication in the Conference Proceedings without corrections or with
minor corrections which were completed by the editor.

A2: Accepted for publication in the Conference Proceedings with minor corrections.

A3: Not accepted for publication in the Conference Proceedings but accepted for
presentation at the Conference.

As described in Table 1, nine and 27 papers were categorized into A1 and A2, respectively and were published
D., 2007). The other 33 papers were rejected for publication in the Conference Proceedings but accepted for
presentation.

After removing the reviewers’ name, their comments and feedback provided in the review forms were sent to the
authors (categories A2 and A3) for necessary actions. The authors were given two weeks to revise their paper and
send back to the Conference committee. The authors of papers categorized A3 were also asked to revise their papers
to be included in the CD Conference Proceedings.

From the reviewers’ comments and feedback, we found that most of the reviewers had provided clear critiques
and suggestions for improving the quality of the papers (A2 and A3 categories). Most of the reviewers had provided
relatively balanced comments on the strengths and limitations of the papers being reviewed enabling the authors to
improve their papers by addressing the reviewers’ suggestions. Examples of reviewers’ comments are provided
below.

*Brief Comment: This paper presented an interesting topic and equally interesting
results. The author makes the case earlier on in his discussion that knowledge in EE
leads to action, but does not return to this point in his conclusion. Apart from
developing his conclusion around the statistical findings, he needs to link more firmly*
with his introductory comments on the relevance of increase or improved knowledge in EE. Please make sure you have someone proof-read any further submissions to reduce the language irregularities. (S106MK; A2 category).

Some reviewers also provided comments using track-change facilities in MS Word. This would help the author in revising the paper. When we received the revised paper, we found that the quality of the revised paper had been much improved compared to the original one.

Another example of thorough and balanced comments and feedback for an A3 categorized paper is described below:

Brief Comment: The topic of the paper is relevant and significant for the conference. The author has made great attempt to write the paper in a clearly way and it is a credit to the author. However, there are lot of rooms for improvement in this paper. First of all, the paper has few theoretical backgrounds. It would be stronger if the author put a section under the theoretical background after the Introduction. This will provide link between past study and the one conducted by the author. Secondly, in respond to the first research question – the author did not provide any convincing data. He or she should give the evidences. Third, the organisation of the findings is somewhat confusing. See detail of the comments in the paper. Fourth, the author needs to justify on his/her scoring scheme for student performance in each factor and in the CPSAT. For example, why he or she consider the percentage score of 41% as satisfactory? Is there any reference that the author can refer to? The discussion on the lowest score of student’s ability in problem solving is missing. Is it as intended or the author forgot it? Finally, the author needs to rewrite the conclusion. This section should be short but concise and sum up for answering the research questions. Some paragraphs in this section are appropriate to be put in the findings and discussion section.

Upon the revision is done, I do believe that the paper deserve to be included in Conference Proceeding or published in a referee journal. So I encourage the authors to write this up for the RECSAM Journal after necessary changes was made. I congratulate the author on his/her efforts.

I have made a number of corrections and comments on the paper using the track changes that I hope are helpful to the author. (S0408EE; A3 category).

As mentioned in their comments, the reviewers also provided editing in the paper. We also found that the revised paper that was included in the CD-ROM Proceedings had been much improved.

Investigating the reviewers’ comments and feedback and the authors’ effort to improve their paper revealed that the peer review process was beneficial for the authors in particular and more specifically it helped maintain the quality of scholarly papers published in the printed Conference Proceedings. A small survey asking for the authors’ comments toward peer review processes was conducted and the results are discussed in the next section.

Authors’ experiences and comments toward the peer review processes

A total of 20 authors who sent their papers for peer review processes responded to the three questions posted via email. Their responses are discussed based on each question.

Question 1: How do you rate the paper review processes: (1) not useful; (2) useful; (3) very useful?
We found in this study that most of the authors rated the reviewing processes as very useful (3-the highest); but moderate commentary was also found saying that the review process was (2) useful – ‘Because it is very detail but lack of advices about research methodology, design, findings or conclusions’ (Author 2).

One author pointed out the punctuality of the review processes and the benefit of using email as communication.

A very positive feature was that the process took place in good time. It was also very good to make use of email as this allowed the process to continue irrespective of where all the
participants were (I was on vacation in Greece for part of the process but email enabled me to keep up). I found referees' comments and, particularly, their questions helpful. (Author 7).

Similarly another author appreciated the use of online (email) communication in the peer review processes (the committee to authors).

Thank you very much for the e-mail. I am very grateful to the secretariat of the conference. I think the paper review processes is very useful and both reviewers provide adequate comments, balance critique and suggestion on my paper. I like very much with on-line revision you provided such that this is easier for us. Thank you again, and hope that I can come for the next conference. (Author 5).

Question 2: Do you think that both reviewers provide adequate comments, balance critique and suggestion for your paper?

In response to the 2nd question, this study documented that most of the authors agreed that the reviewers have provided adequate comments and feedback. Some comments from the authors support this claim:

The suggestions provided by both reviewers enhance me to reflect on the research design and report's writing. (Author 11).

The reviewers gave good formative feedback that enabled me to make the necessary improvements to ensure publication. I think their comments were fair, balanced and informative. (Author 10).

I really want to say thank you to all of you that we have great time in the conference. The review processes are very useful and the reviewers provide adequate comments. We learn a lot from the comments. Thank you for your support. I hope we can meet again soon. (Author 1).

There was consistency in the review of my paper by all reviewers. The comments they made were quite insightful and helped a lot in the bettering of my paper. (Author 14).

These findings support our claims of the effectiveness of the review processes as described in the previous section. Even though not all reviewers were able to provide critiques and comments on the papers they have reviewed, this study documented that generally the peer review process was meaningful and useful. The committee could accomplish its task to maintain the quality of the papers published in the proceedings. The authors were also able to learn in the process.

Question 3: Please provide your comments so that we can improve our paper reviewing for next CoSMEd in 2009.

In response to the third statements, various suggestions were documented. For example, one author expected that the reviewer might provide some corrections (editing) to the paper.

I think that it would be better if the reviewer not only gave comments but also gave some correction to the paper (if possible). (Author 13).

Some authors suggested the possibility of communication between the authors and the reviewers.

There should be provision if reviewers want to make themselves known so that, if they so wish, they could interact further with the presenter during the conference, or so that the presenter can interact with the reviewer if they so desire. (Author 8).

It is better to know who are our reviewers at the end of the process. This is easy for us to get to him/her for further actions. This is important for PHD students like myself who are in the final stages of write-up. (Author 4).
Furthermore, one author provided a relatively comprehensive suggestion on how the next peer review processes might be improved. Issues such as qualitative and quantitative research and commentaries from the reviews were raised.

*Obviously the more information the better. The 5 point scale was good. If possible, fuller comments would be great but I realize that time and energy are finite so one has to be pragmatic!*

There was one issue that I felt could be considered for a future occasion. This concerned reviewers' views about the nature of research. This is an interesting issue in the fields of science and maths education because, while the tradition in science and maths is to view research as the production of new, sound (objective/logical) knowledge, there is a growing view in the education community that research is constructed and may be tentative and contested. One of this year's keynote presenters, Ken Tobin, makes this point very well in his 1993 book, 'The practice of constructivism in Science Education'. I think it would be helpful if reviewers in the future are encouraged to take a view of the nature of research in science and maths education that encompasses both objectivist work and qualitative and exploratory work. The former might be structured in the familiar way: literature, method, results, conclusion. Qualitative research would look rather different from this and could be aimed at generating new theory or new understandings or interpretations of educational processes. So, in short, I would suggest that future referees be encouraged to think beyond the traditional research paradigm of objectivism (because if they don't, they risk being stuck in the past!). I hope this helps. (Author 7).

**CONCLUDING REMARKS**

The peer review process is a tireless effort involving various parties such as a committee, reviewers’ panels, and authors. Nevertheless, despite these challenging obstacles we learned and experienced a process that is worthwhile and meaningful. Having peer reviewed Conference proceedings on time and distributing the results to the delegates was of good value to the Conference.

**REFERENCES**


Appendix A

International Conference on Science and Mathematics Education (CoSMED) 2007

FULL PAPER REFEREEING RESPONSE FORM

Dear Reviewer,
We have sent you a full paper as an attachment to an email for review. Please refer to the paper code in all correspondence preferably by email. Please return this form via FAX TO 60 4 6572541 or email to cosmed@arecam.edu.my within 3 weeks. If unable to complete the review in 3 weeks --
1. report this matter by return email, or
2. contact the secretariat of CoSMED 2007 at SEAMEO RECSAM to discuss a more appropriate time-line

CONFERENCE PAPER SUMMARY EVALUATION AND RECOMMENDATION

(Please fill in non-shaded sections below)

<table>
<thead>
<tr>
<th>Required [essential for fail-safe tracing purposes]</th>
<th>Please write in.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paper Code: ➔</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Required</th>
<th>Title of Paper: ✧</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EVALUATION

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>NOT acceptable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Significance of paper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Appropriateness for this conference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Quality of the research [conceptual/ theoretical/ design/ analysis]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Quality of writing [organization, clarity, style]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RECOMMENDATION

- Accepted for publication in the Conference Proceedings without corrections or with minor corrections which were completed by the editor.
- Accepted for publication in the Conference Proceedings with minor corrections. (Please refer to the comments given by the paper reviewers.) Please have the corrections completed and sent to the CoSMED secretariat in 2 weeks.
- Not accepted for publication in the Conference Proceedings but accepted for presentation at the Conference. The paper will be included in CD-ROM to be distributed during the conference.
- Not accepted for presentation
STUDENTS’ PERCEPTIONS OF ASSESSMENT PROCESS:
QUESTIONNAIRE DEVELOPMENT AND VALIDATION

Bruce G. Waldrip
University of Southern Queensland
Australia
Darrell L. Fisher
Curtin University of Technology
Australia
Jeffrey P. Dorman
Australian Catholic University
Australia

ABSTRACT

Research aimed at developing and validating an instrument to assess middle school students’ perceptions of assessment was conducted. Following a review of literature, a tentative 6-scale instrument of 48 items was trialled with a sample of 320 students in 7 Australian schools. Based on internal consistency reliability data and exploratory factor analysis, refinement decisions resulted in a 5-scale instrument called the Student Perceptions of Assessment Questionnaire (SPAQ). The scales of the SPAQ are Congruence with Planned Learning, Authenticity, Student Consultation, Transparency, and Diversity. A sample of 3,098 students in 150 classrooms was used to validate the final SPAQ.

INTRODUCTION

Despite the growth in emancipatory conceptualisations of classrooms that embrace a constructivist epistemology, little contemporary evidence exists to support the view that students are genuinely involved in decision-making about their assessment tasks. That is, forms of assessment and specific assessment tasks employed in schools are overwhelmingly decided by teachers and administrators. Furthermore, even though reports like The Status and Quality of Teaching and Learning in Australia (Goodrum, Hackling, & Rennie, 2001) have asserted that assessment is a key component of the teaching and learning process, teachers tend to utilise a very narrow range of assessment strategies on which to base feedback to parents and students. In practice, there is little evidence that teachers actually use diagnostic or formative assessment strategies to inform planning and teaching (Radnor, 1996). This could be due to teachers feeling that they need to ‘sacrifice learning with understanding for the goal of drilling students in the things for which they will be held accountable’ (Hobden, 1998, p. 221).

Historically, teachers have received substantial levels of advice on assessment practices. Harlen (1998) advises teachers that both oral and written questions should be used in assessing students’ learning. The inclusion of alternative assessment strategies, such as teacher observation, personal communication, and student performances, demonstrations, and portfolios, have been offered by experts as having greater usefulness for evaluating students and informing classroom instruction (Brookhart, 1999; Stiggins, 1994). Based on research with teachers, Barksdale-Ladd and Thomas (2000) identified five best practices in assessment:

- providing feedback to help students improve their learning;
- conceptualising assessment as part of a student’s work, which can go into a working portfolio;
- providing flexibility so that assessment does not dominate the curriculum;
- ensuring that assessment informs instruction to help teachers improve their teaching, thereby ensuring student learning; and
- using more than one measuring stick to assess students’ learning.

Reynolds, Doran, Allers, and Agruso (1995) argued that for effective learning to occur, congruence must exist between instruction, assessment and outcomes.

Few textbooks on classroom teaching and assessment suggest a substantive role for students in developing assessment tasks. This position is historically and culturally based and is rooted in an outdated “assembly-line” view of learning in which recitation of facts is highly prized. In today’s information age, jobs are increasingly demanding higher levels of literacy skill and critical thinking and these demands require students to actively engage and monitor their learning rather than passively receive knowledge. This requires a fundamental review of how teachers involve students in assessment tasks (Rogoff, 2001).

An effective assessment process should involve a two-way communication system between teachers and their students. Historically, teachers have used testing instruments to transmit to the student and their parents what is really important for the student to know and do. While this reporting tends to be in the form of a grade, the form and design of assessment can send subtle messages on what is important. There has been a substantial amount of research into
types of assessment but very little research into students’ perceptions of assessment (see e.g., Black & Wiliam, 1998; Crooks, 1998; Plake, 1993, Popham, 1997).

In one of the few studies conducted on students’ perceptions of assessment, an American sample of 174 students in Years 4 to 12 responded to a specially-designed questionnaire (Schaffner, Bury, Stock, Cho, Boney, & Hamilton, 2000). This research, which also elicited teachers’ self-reported perceptions of competence in the design and implementation of assessment tasks, found that teachers were not asking students about what should be included in assessment tasks. By including students in the teaching – testing – grading cycle, the validity of the assessment processes can be enhanced and invalid assessment instruments that result in very high failure rates can be avoided (see e.g., Steinberg, 2000).

THE PRESENT STUDY

Aim

The aim of the present study was to develop and validate an instrument to assess students’ perceptions of assessment tasks for use with middle school students.

Sample

In the initial trial validation, a sample of 320 middle school students from Western Australia and Queensland responded to the tentative form of the Students’ Perceptions of Assessment Questionnaire (SPAQ) described below. The final form was administered to 3,098 students in 150 classrooms.

Methodological approach to development of the SPAQ

Fraser (1986) and Hase and Goldberg (1967) identified four approaches to the development of instruments: intuitive-rational, intuitive-theoretical, factor analytic and empirical group discriminative. While intuitive-rational and intuitive-theoretical scales rely on the nomination of items to tentative scales prior to questionnaire administration, factor analytic scales employ factor analysis to group items solely on the responses of a sample of the target population being investigated. Empirical group discriminative scales also require test administration prior to scale formation but they are align with an external criterion by selecting items that maximise discrimination between groups of respondents. The SPAQ was developed using an intuitive rational approach to instrument design and validation.

The validity of intuitive-rational scales rests partly on the subjective opinions of the investigators and other experts. There are three procedural steps to intuitive-rational scale development: (1) identification of salient dimensions, (2) writing sets of test items that are linked conceptually with each salient dimension, and (3) field testing the questionnaire. Identifying salient dimensions usually involves a review of literature and utilises the researchers’ academic expertise. Writing test items utilises the subjective opinions of researchers with scale development knowledge. Field testing involves administration of the questionnaire to a sample of the target population and studying the internal consistency (usually employing the Cronbach α coefficient as an index) and discriminant validity (using the mean correlation of a scale with the remaining scales as a convenient index) of each scale. Factor analysis can also be used to assist with scale refinement.

DEVELOPMENT OF A TENTATIVE FORM OF THE STUDENTS’ PERCEPTIONS OF ASSESSMENT QUESTIONNAIRE (SPAQ)

Identification of salient dimensions

As indicated above, the first step in the intuitive-rational approach is the identification of salient dimensions. An extensive literature review was conducted with an analysis of over 64 policy and research papers on exemplary and effective assessment practices, characteristics, principles, and techniques. For example, McMillan (2000) identified authenticity, feedback opportunities, validity, fairness, ethical, efficient, feasible and utilising multiple methods as important characteristics of assessment in schools. The North West Regional Educational Laboratory’s (1995) research synthesis on effective schooling practices lists many characteristics of quality assessment in schools including: reviewing assessment instruments and methods for cultural and other bias, aligning assessments of student performance with the written curriculum and actual instruction, teaching students to evaluate their own work through peer and self-assessment.

Dietel, Herman and Knuth (1991) noted several important characteristics of good assessment. Such assessment: provides accurate estimates of student performance, is consistent and reliable, tests the full range of knowledge and skills, and is free of extraneous factors that confuse students. Furthermore, they argue that good assessment involves
students in setting goals and criteria for assessment and performing tasks that measure meaningful instructional activities. Such activities should be contextualised in real-world situations. Stern and Algren’s (2002) review of assessment in science curriculum materials employed three assessment criteria: the extent to which assessment tasks align with the goals of the materials, the extent to which the items focus on student understanding, and the extent to which assessment informs instruction.

Another important source for the present study was the Perceptions of Assessment questionnaire developed by Schaffner et al. (2000). This 55-item questionnaire asked students to respond on “how you feel about the way your teacher finds out how much you have learned”. Two scales of this questionnaire are particularly relevant to the present study: Fairness Issues, and Student Input into Grading. In Australia, the Student Learning Preferences questionnaire (Gough, Waldrip, Tytler, Beeson, & Sharpley, 2002) was reviewed.

Based on this review of policy and research papers, the following tentative dimensions were deemed salient to the present instrument: Congruence with Planned Learning, Diverse Methods, Authenticity, Student Consultation, Transparency, and Accommodation of Student Diversity. Table 1 shows these dimensions and their common sense definitions. These definitions were based on the literature review described above.

Table 1
Description of the SPAQ (Tentative Form)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruence with Planned Learning</td>
<td>The extent to which assessment tasks align with the goals, objectives and activities of the learning program.</td>
</tr>
<tr>
<td>Diverse Methods</td>
<td>The extent to which multiple, varied assessment tasks are employed.</td>
</tr>
<tr>
<td>Authenticity</td>
<td>The extent to which assessment tasks feature real life situations that are relevant to the learner.</td>
</tr>
<tr>
<td>Student Consultation</td>
<td>The extent to which students are consulted and informed about the forms of assessment tasks being employed.</td>
</tr>
<tr>
<td>Transparency</td>
<td>The extent to which the purposes and forms of assessment tasks are well-defined and clear to the learner.</td>
</tr>
<tr>
<td>Accommodation of Student Diversity</td>
<td>The extent to which all students have an equal chance at completing assessment tasks.</td>
</tr>
</tbody>
</table>

Writing of test items

The second step in the intuitive-rational approach to scale development requires sets of items that are conceptually linked with each salient dimension to be written. Because of the need to limit the length of the instrument, it was decided to write a set of 11 items for each dimension and subject these to measurement scrutiny with a goal of having eight per scale in the tentative instrument. Accordingly, a pool of 66 items was checked for faults and ambiguities by a group of academics with expertise in educational and psychological measurement and school assessment. Particular attention was paid to the face validity and the scale allocation of each item. These items employed a 4-point Likert scale response: Almost Never, Sometimes, Often, Almost Always. The result of this review process was a 48-item instrument with six scales. Each scale has eight items.

Field testing

In line with the third step in the intuitive-rational approach to scale development, the SPAQ (tentative form) was field tested. The sample of 320 Australian middle school students describe above responded to the SPAQ (tentative form). The internal consistency reliability (Cronbach Coefficient α) of each scale and the discriminant validity (mean correlation of each scale with the remaining scales) were computed. Table 2 shows these values.

Apart from the Diverse Methods scale, all scales had satisfactory internal consistency reliability (see Table 2). Discriminant validity data indicated that the scales do overlap. And exploratory factor analysis with varimax rotation revealed low factor loading for items of the Diverse Methods scale.
Table 2
Validation Data for SPAQ (Tentative Form)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Internal Consistency Reliability (Coefficient α)</th>
<th>Discriminant Validity (Mean Correlation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruence with Planned Learning</td>
<td>.78</td>
<td>.45</td>
</tr>
<tr>
<td>Diverse Methods</td>
<td>.48</td>
<td>.34</td>
</tr>
<tr>
<td>Authenticity</td>
<td>.76</td>
<td>.51</td>
</tr>
<tr>
<td>Student Consultation</td>
<td>.69</td>
<td>.55</td>
</tr>
<tr>
<td>Transparency</td>
<td>.88</td>
<td>.55</td>
</tr>
<tr>
<td>Accommodation of Student Diversity</td>
<td>.68</td>
<td>.44</td>
</tr>
</tbody>
</table>

Refinement decisions

Based on the above data, and a review of the scales, the following decisions were implemented. First, the Diverse Methods scale was deleted. This decision was based on two grounds: poor internal consistency reliability and conceptual overlap with the Accommodation of Student Diversity scale. Second, the Accommodation of Student Diversity scale was renamed Diversity. Third, several items were modified to enhance their face validity. Finally, it was decided to reduce the number of items in each scale to six. This decision was based on the data which indicated no appreciable loss of internal consistency reliability for the five scales. Additionally, shorter scales enhance the overall economy of administration of the instrument. A copy of this final form of the SPAQ is in the Appendix.

Table 3
Descriptive Information for the SPAQ (Final Form)

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Description</th>
<th>Internal Consist. (Coeff’t α)</th>
<th>Discrim. Validity (Mean Corr.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruence with Planned Learning</td>
<td>The extent to which assessment tasks align with the goals, objectives and activities of the learning program.</td>
<td>.77</td>
<td>.45</td>
</tr>
<tr>
<td>Authenticity</td>
<td>The extent to which assessment tasks feature real life situations that are relevant to the learner.</td>
<td>.72</td>
<td>.50</td>
</tr>
<tr>
<td>Student Consultation</td>
<td>The extent to which students are consulted and informed about the forms of assessment tasks being employed.</td>
<td>.68</td>
<td>.55</td>
</tr>
<tr>
<td>Transparency</td>
<td>The extent to which the purposes and forms of assessment tasks are well-defined and clear to the learner.</td>
<td>.86</td>
<td>.58</td>
</tr>
<tr>
<td>Diversity</td>
<td>The extent to which all students have an equal chance at completing assessment tasks.</td>
<td>.74</td>
<td>.45</td>
</tr>
</tbody>
</table>
Table 4  
*Factor Loadings for 30 Items of the SPAQ (Final Form)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor 1</td>
</tr>
<tr>
<td>CPL1</td>
<td>.70</td>
</tr>
<tr>
<td>CPL2</td>
<td>.54</td>
</tr>
<tr>
<td>CPL3</td>
<td>.71</td>
</tr>
<tr>
<td>CPL4</td>
<td>.60</td>
</tr>
<tr>
<td>CPL5</td>
<td>.57</td>
</tr>
<tr>
<td>CPL6</td>
<td>.70</td>
</tr>
<tr>
<td>A1</td>
<td>.56</td>
</tr>
<tr>
<td>A2</td>
<td>.33</td>
</tr>
<tr>
<td>A3</td>
<td>.32</td>
</tr>
<tr>
<td>A4</td>
<td>.63</td>
</tr>
<tr>
<td>A5</td>
<td>.70</td>
</tr>
<tr>
<td>A6</td>
<td>.44</td>
</tr>
<tr>
<td>SC1</td>
<td></td>
</tr>
<tr>
<td>SC2</td>
<td></td>
</tr>
<tr>
<td>SC3</td>
<td></td>
</tr>
<tr>
<td>SC4</td>
<td></td>
</tr>
<tr>
<td>SC5</td>
<td></td>
</tr>
<tr>
<td>SC6</td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td></td>
</tr>
<tr>
<td>T2</td>
<td></td>
</tr>
<tr>
<td>T3</td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td></td>
</tr>
<tr>
<td>T5</td>
<td></td>
</tr>
<tr>
<td>T6</td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td></td>
</tr>
<tr>
<td>D2</td>
<td></td>
</tr>
<tr>
<td>D3</td>
<td></td>
</tr>
<tr>
<td>D4</td>
<td></td>
</tr>
<tr>
<td>D5</td>
<td></td>
</tr>
<tr>
<td>D6</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Factor loadings below .30 have been omitted. CPL: Congruence with Planned Learning, A: Authenticity, SC: Student Consultation, T: Transparency, S: Diversity
VALIDATION OF THE FINAL FORM OF THE SPAQ

The final form of the SPAQ consists of five 6-item scales assessing Congruence with Planned Learning, Authenticity, Student Consultation, Transparency, and Diversity. Table 3 shows internal consistency reliability and discriminant validity data for the final form of the SPAQ based on the sample of 320 Australian students. All scales have satisfactory internal consistency reliability. Discriminant validity data indicate that the scales overlap. However, their conceptual distinctiveness warrants retention of all five scales.

Exploratory factor analysis with a varimax rotation revealed five factors accounting for 51.5% of variance in scores. Table 4 shows that 27 of the 30 items had loadings in excess of .30 on their *a priori* scales. This indicates a sound instrument structure.

The final version was administered to 3,098 students in 150 classrooms. Table 5 shows that the final version had acceptable reliability. The reliability of the SPAQ was evaluated by subjecting the data to item analysis and the internal consistency/reliability (Cronbach alpha reliability) for the factors are shown in Table 5. The data in the table shows that for this sample, the alpha reliability ranged from 0.62 to 0.82 suggesting that each SPAQ scale have acceptable reliability, especially for scales containing a relatively small number of items. The mean partial correlation of a scale with other scales was used as a convenient measure of the discriminant validity of the SPAQ. The mean partial correlation value of a scale with other scales is reported in table 5. The mean correlations ranged from 0.38 to 0.46 indicating that the SPAQ measures distinct, although somewhat overlapping aspects of dimensions of assessment. Different teacher tend to use a different selection of assessment tasks. For an instrument to be valid and reliable, it should detect these differences. *Eta*² is a statistical concept that guides researchers on these differences. The *Eta*² data was computed using a one-way ANOVA with class membership as the main effect. The instrument recorded statistically significant *Eta*² values range 0.14 – 0.20, *p* = 0.000) for all scales suggesting its suitability in locating differences students’ perceptions in different classes.

Table 5
Validation Data for SPAQ (Final Form)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Internal Consistency Reliability (Coefficient α)</th>
<th>Discriminant Validity (Mean Correlation)</th>
<th>ANOVA Results (Eta²)</th>
<th>Scale Mean (range 1-4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congruence with Planned Learning</td>
<td>.72</td>
<td>.38</td>
<td>0.15</td>
<td>3.07</td>
</tr>
<tr>
<td>Authenticity</td>
<td>.82</td>
<td>.43</td>
<td>0.20</td>
<td>2.33</td>
</tr>
<tr>
<td>Student Consultation</td>
<td>.72</td>
<td>.44</td>
<td>0.20</td>
<td>2.25</td>
</tr>
<tr>
<td>Transparency</td>
<td>.82</td>
<td>.46</td>
<td>0.14</td>
<td>3.04</td>
</tr>
<tr>
<td>Diversity</td>
<td>.62</td>
<td>.44</td>
<td>0.15</td>
<td>2.57</td>
</tr>
</tbody>
</table>

The average scale item mean values in each of the five scales are shown in table 5. The values ranged from 2.33 to 3.07. The average scale item mean values were greatest for Congruence with Planned Learning and Transparency while it was lowest for Authenticity, Student Consultation on Assessment and Diversity. The higher average scale item mean values for Congruence with Planned Learning and Transparency scales suggest that in general students perceived that often the assessment covered what they learned in their classes and there was often transparency in their assessment. However, the lower value for Student Consultation on Assessment suggests a low level consultation with students. The data for the remaining three scales, Authenticity and use of Diversity in Assessment scales suggests a week link between assessment and application of knowledge to daily life, and, only sometimes their assessment is catered for students’ diversity. The overall analysis of students’ perception data suggests a scope for improvement. It is possible that a change is required at the part of teachers and persons involves in assessment.

CONCLUSION

This paper has reported the initial development and validation of an instrument to assess middle school students’ perceptions of assessment. As indicated earlier in this paper, students have been left out of assessment deliberations in spectacular fashion for many years and the availability of a validated instrument could facilitate student involvement in the process. Following an intuitive-rational approach to instrument development, a
tentative 6-scale instrument was field tested and subsequently a 5-scale structure was accepted. The development of this instrument, the Students’ Perceptions of Assessment Questionnaire (SPAQ) was the initial stage of a larger study.

This research is different in that it examines their perceptions of the process of assessment. In fact, much previous research examines the impact of student peer-assessment on learning. How teachers respond to these perceptions will be varied. Some teachers will accept them as is and try to teach students in somewhat mechanistic ways that will reinforce these perceptions. Other teachers will endeavour to make changes to how students perceive the assessment process. As the U.N. Convention on Children’s Rights infer, these teachers will engage students in the assessment process and will give these students a voice that will illuminate students’ perceptions of assessment. There will be students who believe that the assessment process is detached from them and that the student should have no input into the process. One could then examine whether involving the students in the process does change their views.

REFERENCES


Acknowledgments

The research described in this paper was supported in part by an Australian Research Council Discovery Grant DP0451981.
Appendix

Students’ Perceptions of Assessment Questionnaire (SPAQ)

1. Questions in science tests what I know.
2. My science assignments/tests examines what I do in class.
3. My assignments/tests are about what I have done in class.
4. How I am assessed is like what I do in class.
5. How I am assessed is similar to what I do in class.
6. I am assessed on what the teacher has taught me.
7. I am asked to apply my learning to real life situations.
8. My science assessment tasks are useful in everyday things.
9. I find science assessment tasks are relevant to what I do outside of school.
10. Assessment in science tests my ability to apply what I know to real-life problems.
11. Assessment in science examines my ability to answer every day questions
12. I can show others that my learning has helped me do things.
13. In science I am asked about the types of assessment that are used.
14. I am aware how my assessment will be marked.
15. I can select how I will be assessed in science.
16. I have helped the class develop rules for assessment in science.
17. My teacher has explained to me how each type of assessment is to be used.
18. I have a say in how I will be assessed in science.
19. I understand what is needed in all science assessment tasks.
20. I know what is needed to successfully complete a science assessment task.
21. I am told in advance when I am being assessed.
22. I am told in advance on what I am being assessed.
23. I am clear about what my teacher wants in my assessment tasks.
24. I know how a particular assessment task will be marked.
25. I have as much chance as any other student at completing assessment tasks
26. I complete assessment tasks at my own speed.
27. I am given a choice of assessment tasks.
28. I am given assessment tasks that suit my ability.
29. When I am confused about an assessment task, I am given another way to answer it.
30. When there are different ways I can complete the assessment.

Scale Allocations:
Congruence with Planned Learning: 1-6
Authenticity: 7-12
Student Consultation: 13-18
Transparency: 19-24
Diversity: 25-30

568
This paper examines the department-level work environment of early career secondary school science teachers in New Zealand. Fifty-three secondary school science teachers in their third, fourth or fifth year of teaching completed the Department-Level Environment Questionnaire (DLEQ), an instrument adapted from the School-Level Environment Questionnaire (SLEQ) (Fisher & Fraser, 1990). A comparison between actual and preferred perceptions showed statistically significant differences on all scales and indicated that the teachers preferred a more favourable level of each of the DLEQ scales. That is, less Work Pressure and an increase in the other scales. Two of the greatest differences were found for Resource Adequacy and Professional Interest. Two of the smallest differences were found for Affiliation and Empowerment. Follow-up interviews were conducted with nine of the participants to gain a richer understanding of the participants’ perceived actual work environments and how they would prefer their work environment to be, in the area of Resource Adequacy, Professional Interest, Affiliation and Empowerment. Factors that either support or hinder early career secondary school teachers’ in their science department work environments are discussed and improvements to these environments are suggested.
and the degree of clarity of expectation and the extent to which the environment maintains control and is responsive to change.

**Relationship Dimension**

Integral to the work environment is the relationship with community, parents, colleagues and students. While a positive relationship with the community, parents has been noted as a significant factor for job satisfaction (Ingersoll, 2001) positive professional relationships with students and colleagues have been noted as more significant (Kim & Loadman, 1994).

Students are the critical context for teachers’ work. Teachers often describe their work and the rewards they receive in terms of student-teacher relationships (Lortie, 1975; McLaughlin & Talbert, 2001; Yee, 1990). Student behaviour, their motivation and accomplishments can either affirm or damage the confidence of teachers (Ingersoll, 2001; McLaughlin & Talbert).

Relationships with colleagues and professional socialisation have also been identified as influences on teacher quality and retention (Yee, 1990). The relational aspect that is often described in the literature is the need for support. In particular, the literature in this area has suggested that lack of administrative support and leadership impacts on job satisfaction and the willingness for teachers to remain in the profession (Betancourt-Smith, Inman, & Marlow, 1994; Billingsley, 1993; Certo & Fox, 2002; Ingersoll, 2001; Stockard & Lehman, 2004; Weiss, 1999).

One of the areas of administrative support is associated with discipline. If teachers feel supported regarding student discipline and managing difficult or unmotivated students then they are more likely to remain in teaching (Dewar et al., 2003; Yee, 1990).

Opportunities for collegial interaction and emotional support from colleagues (Yee, 1990) and a work environment in which there is a sense of collaboration and community among staff, have all been cited as factors that are linked to job satisfaction and contribute to a lower attrition rate (Billingsley, 1993; Kim & Loadman, 1994; Odell & Ferraro, 1992).

**Personal Development Dimension**

If one considers teaching as a social activity (Fullan & Hargreaves, 1996) then the intrinsic rewards of professional challenge and autonomy contribute to a positive work environment. These factors have been indicated in affecting job satisfaction in positive ways (Kim & Loadman, 1994). The intrinsic rewards of professional challenge and opportunities for professional development have also been found to positively affect job satisfaction and are significant in the creation of a positive work environment (Kim & Loadman; Shann, 1998; Yee, 1990). Professionalism and recognition from other teachers and opportunities to work with teachers in a cooperative manner has also been cited as important in developing a positive work environment (Cameron, 2003; Inman & Marlow, 2004) and may impact on a teacher’s readiness to stay in the profession.

**Systems Maintenance and Change Dimension**

Systemic factors such as class size and timetabling have an impact on teacher retention (Ingersoll, 2001; Kirby, Berends, & Naftel 1999). Reduction in class size may increase job satisfaction (Kim & Loadman, 1994). Associated with timetabling is the problem of workload with inappropriate workloads and hectic schedules being linked to a decrease in job satisfaction (Certo & Fox, 2002; Yee, 1990). Another outcome of poor timetabling is inadequate planning time (Darling-Hammond, 1996; Ingersoll, 2001). This lack of planning time results in teachers not having time to meet with other teachers for professional growth and development (Darling-Hammond). Inadequate resources and support in order to teach successfully have also been reported as the reason beginning teachers left teaching (Dewar et al., 2003; Johnson & Birkeland, 2003).

Early career science teachers’ everyday work experience resides in science departments. However, little research has been conducted about early career teachers or about secondary school subject departments so it is fitting to carry out research about early career teachers’ perceptions of their actual and preferred subject department environments in their secondary schools to gain a better understanding of the social world in which early career teachers work and how they would prefer their work environment. This in turn may establish the kind of work environment that either supports early career science teachers in their work as a teacher and influences them to either remain in teaching or influences them to leave teaching.

Literature about teacher retention and the importance of the work environment led to the following questions:

- What are the perceived differences between the preferred and actual subject department work environments of early career secondary school science teachers?
- What factors in science department work environments either supports or hinders early career secondary school teachers’ work?
RESEARCH DESIGN

A sequential explanatory model, a mixed methods design, in which a quantitative phase precedes a qualitative phase was used (Creswell, 2003; Tashakkori & Teddlie, 2003). A mix of both qualitative and quantitative data collection was used in order to provide a range of data and consequently gain a more in-depth and enriched understanding of the working environment (Tobin & Fraser, 1998).

The Quantitative Phase

The quantitative data was gathered through participants answering the Department-Level Environment Questionnaire (DLEQ), an instrument adapted from the School-Level Environment Questionnaire (SLEQ) (Fisher & Fraser, 1990). The SLEQ is a robust instrument that has been used widely to examine school environments in the secondary school. In addition, validation has been established previously (Fisher, Fraser, & Wubbels, 1993; Fraser, 1994).

There have been a number of studies that have successfully developed instruments that have been parented by the SLEQ. Examples include the Catholic School Environment Questionnaire (CSEQ; Dorman & Fraser, 1996) and the University-Level Environment Questionnaire (ULEQ; Dorman, 1999) and the Special School Level Environment Questionnaire (SSLEQ; Adams & Adams, 2000). Most of the early use of the SLEQ was conducted in Australia. Subsequently, it has been suitably modified for use in other countries (e.g., Mailula, Rudiger, Aldridge, & Fraser, 2003; Wahyudi & Fisher, 2006).

Given the SLEQ has been successfully modified suggests that the SLEQ could be used to develop a questionnaire that could be used at the secondary school subject department level rather than the school level and be successfully used in the New Zealand setting. In this study, by altering the questionnaire slightly a more appropriate questionnaire for the department-level work environment could be achieved while at the same time still assessing teachers’ perceptions of psychosocial dimensions of the environment.

Table 1 describes the DLEQ scales used in this research and clarifies the meaning of the scales by providing descriptions of the scale, sample items and the association with Moos’ three dimensions of psychosocial environments.

Each of the eight scales is comprised of seven items, bringing the total number of items to 56. Of the 56 items 19 are scored in the reverse manner. Each item is scored on a five-point Likert scale: (viz. Strongly Agree = 5, Agree = 4, Not sure = 3, Disagree = 2 and Strongly Disagree = 1). Both actual and preferred versions of the instrument were used.

Fifty three early career science teachers responded to the questionnaire. The teachers taught in New Zealand secondary schools across a range of deciles and school roll size. In addition to the DLEQ, the teachers completed a profile sheet in which demographic and biographical data was sought.
Table 1
*Description of Scales in the DLEQ and Their Classification According to Moos’ Scheme*

<table>
<thead>
<tr>
<th>Scale Name</th>
<th>Description of Scale</th>
<th>Sample Item</th>
<th>Moos’ General Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Support</td>
<td>There is good rapport between teachers and students and student behavior in a responsible self-disciplined manner.</td>
<td>Most students are pleasant and friendly to teachers in this department (+)</td>
<td>Relationship</td>
</tr>
<tr>
<td>Affiliation</td>
<td>Teachers can obtain assistance, advice and encouragement and are made to feel accepted by colleagues.</td>
<td>I feel that I could rely on my colleagues in the department for assistance if I needed it. (+)</td>
<td></td>
</tr>
<tr>
<td>Professional Interest</td>
<td>Teachers discuss professional matters, show interest in their work and seek further professional development.</td>
<td>Teachers in the department discuss teaching methods and strategies with each other. (+)</td>
<td>Personal Development or Goal Orientation</td>
</tr>
<tr>
<td>Empowerment</td>
<td>Teachers are empowered and encouraged to be involved in decision making processes.</td>
<td>Decisions about the running of this department are usually made by the Head of Department or a small group of teachers. (-)</td>
<td>System Maintenance and System Change</td>
</tr>
<tr>
<td>Mission Consensus</td>
<td>Consensus exists within the staff about the goals of the department.</td>
<td>Teachers agree on the department’s overall goals. (+)</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>The department is in favour of planned change and experimentation, and fosters individualisation.</td>
<td>Teachers in the department are encouraged to be innovative in this department. (+)</td>
<td></td>
</tr>
<tr>
<td>Resource Adequacy</td>
<td>Support personnel, facilities, finance, equipment and resources are suitable and adequate.</td>
<td>The supply of equipment and resources is inadequate. (-)</td>
<td></td>
</tr>
<tr>
<td>Work Pressure</td>
<td>The extent to which work pressure dominates the department environment.</td>
<td>Teachers have to work long hours to complete all their work. (+)</td>
<td></td>
</tr>
</tbody>
</table>

Once the questionnaires were returned a number of different descriptive statistics were calculated. The means and standard deviations for each of the scales on both the actual and preferred versions were determined. In addition, the internal consistency for each scale was calculated using Cronbach’s alpha reliability measure. The discriminant validity, the measure of the correlation of the scale with the other seven scales was also established. Paired sample *t*-tests were calculated in order to establish whether teacher perceptions between their actual department environment and their preferred department environment were significantly different.

Individual questionnaires of those teachers who were going to be interviewed were also analysed. Aggregated scores for the individual teachers were calculated and analysed for indications of how they perceived their actual department environment and their preferred department environment. Outliers of particular items within scales and similarities and differences in mean scores between the individual teacher and the group of 53 teachers were also examined.

While the sample is not large for the quantitative phase, the number selected to answer the questionnaire is considered adequate for simple statistical analysis and is also a manageable sample within the confines of this research.
Qualitative Phase

Qualitative data were gathered through interviewing nine early career teachers who had answered the DLEQ. A semi-structured interview format using an interview guide was used. This involved the teachers being interviewed about their answers to the DLEQ and to obtain further data about their work lives.

Data were analysed for emergent themes within an interpretivist paradigm (Robottom & Hart, 1993). The analysis of the qualitative data drew mostly upon Miles and Huberman’s (1994) approach. Data reduction began which involved initial editing and summarising the data, then coding and memoing and finally conceptualising and explaining the data (Miles & Huberman; Punch, 1998). Themes were identified (Tesch, 1990) and conclusions drawn and verified (Miles & Huberman).

FINDINGS

The Cronbach alpha scores were determined for the sample in this study. In most cases satisfactory internal consistency was achieved as values were greater than 0.6 (Nunnally, 1967, 1978). However, for the scales of Empowerment and Resource Adequacy on the preferred version a much improved alpha score was achieved by removing one specific item for each scale during analysis. The range of results of the mean correlations of each scale with the other scales ranged from 0.12 to 0.46. These results are satisfactory and show that the DLEQ has sufficient levels of discriminant validity and measures distinct, but somewhat overlapping aspects of the department environment.

Descriptive analyses were used to examine how early career science teachers view their actual and preferred secondary school department work environment. Table 2 provides the means, standard deviations, t-test results and differences that were recorded between the early career science teachers’ perceived department-level work environment and their perceived preferred department-level work environment. The t-test results show extremely significant differences between actual and preferred scores for all scales.

Table 2
Scale Means and Standard Deviations for Early Career Science Teachers’ Scores on the Eight Scales of the DLEQ

<table>
<thead>
<tr>
<th>Scale</th>
<th>Actual</th>
<th>Preferred</th>
<th>Actual Deviation</th>
<th>Preferred</th>
<th>Mean difference (Preferred - actual)</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>3.67</td>
<td>4.50</td>
<td>0.63</td>
<td>0.43</td>
<td>0.83</td>
<td>9.34*</td>
</tr>
<tr>
<td>Support</td>
<td>4.24</td>
<td>4.62</td>
<td>0.62</td>
<td>0.37</td>
<td>0.38</td>
<td>5.50*</td>
</tr>
<tr>
<td>Affiliation</td>
<td>3.42</td>
<td>4.34</td>
<td>0.65</td>
<td>0.40</td>
<td>0.92</td>
<td>11.40*</td>
</tr>
<tr>
<td>Professional</td>
<td>3.40</td>
<td>4.20</td>
<td>0.58</td>
<td>0.43</td>
<td>0.80</td>
<td>10.50*</td>
</tr>
<tr>
<td>Interest</td>
<td>3.27</td>
<td>3.61</td>
<td>0.56</td>
<td>0.48</td>
<td>0.34</td>
<td>4.87*</td>
</tr>
<tr>
<td>Mission</td>
<td>3.44</td>
<td>4.21</td>
<td>0.66</td>
<td>0.42</td>
<td>0.77</td>
<td>8.63*</td>
</tr>
<tr>
<td>Consensus</td>
<td>3.52</td>
<td>4.49</td>
<td>0.80</td>
<td>0.51</td>
<td>1.17</td>
<td>9.05*</td>
</tr>
<tr>
<td>Empowerment</td>
<td>3.75</td>
<td>2.65</td>
<td>0.58</td>
<td>0.59</td>
<td>-1.10</td>
<td>9.51*</td>
</tr>
</tbody>
</table>

Early career teachers N=53  *p<0.001

Scale mean scores ranged from 3.27 to 4.24 for the teachers’ actual version and 2.65 to 4.62 for the preferred version. Overall, the scale means indicate that for all scales the early career teachers would prefer a more favourable level of each DLEQ dimension than they currently perceive occurs in their science departments. That is, less Work Pressure and an increase in the other dimensions.

The differences in preferred average item means and the actual average item means for each scale could suggest the level of satisfaction of this dimension within New Zealand secondary school science departments. The two scales with the most significant mean differences were Resource Adequacy and Professional Interest. The scales with the smallest differences in mean scores were Affiliation and Empowerment. This paper focuses on these four scales.
Resource Adequacy

The large difference in means between actual and preferred scores for Resource Adequacy suggests that teachers identify this aspect as a key area that they wanted improved in their science departments. The interview data offered further evidence regarding the perceived actual work environment with respect to Resource Adequacy.

On the whole, the teachers who were interviewed believed that they were relatively well resourced in terms of personnel, facilities, finance, equipment and resources. All the early career teachers had their own classroom or a personal workspace. The science departments had at least one lab technician that would support the staff with practical experiments. Most departments had basic science equipment and the teachers believed their teaching was not being hampered by a lack of science equipment.

In departments that were well equipped they were also perceived as well organised with department schemes and print resources. However, even teachers who would describe their department as well resourced would prefer greater resources particularly in the area of ICT.

Three of the teachers, Keith, Cathy and Robert did not believe their department was well organised. Associated with this was a lack of suitable equipment and resources. These teachers found it frustrating when equipment or textbooks were too old as it interfered with the ways in which they wanted to teach and the classroom climate they wanted to create. Keith exemplifies the problems with poor resourcing and the impact it has on his teaching:

"I opened a box when I got here of resources from 1976 which was before I was born which I thought was just a joke considering that science is one of the subjects in the curriculum that changes on a daily basis, ... don’t know if it had been used recently but that was just ridiculous and it wasn’t the only example. ... that frustrates me so much because I’ve actually been used to a quite a lot of computer stuff and now I can’t use the range."

Keith (Male)

On the other hand, for those who had a positive experience, they stated systems of resourcing and discipline helped them become more effective teachers:

"We've got good resources at our school. We have a lot of support in our department. If students are being disruptive we’ve got certain steps that we follow ... yes there’s good steps and methods to deal with disruptive students and there’s support for us."

Belinda (female)

Professional Interest

For the Professional Interest scale there was also a large difference between preferred and actual mean scores indicating the desire by teachers to improve this aspect of the work environment. During the interviews the teachers indicated it was important for teachers to share ideas about teaching.

The opportunity to discuss professional matters occurred in ad hoc ways. The conversations tended to be 'water cooler' conversations and happened when teachers gathered together over morning tea or lunch. The focus of science department meetings was rarely about teaching and learning. Administrative matters dominated the meetings and the teachers found this frustrating.

In the process of sharing ideas it was important to be listened to and have their ideas considered. Keryn who felt her ideas were valued in her department reflected on why this was important:

"Yeah, if you’re given the brush off and everything you say is regarded as being stupid or whatever, that’s well it’s not very nice first of all. You want to think that your ideas are being considered and that they’re as valid as anyone else’s, so yeah I think it is important that your opinion is at least considered."

Keryn (Female)

On the other hand, Cathy did not feel her ideas were welcomed and she felt ‘mocked’ by her senior colleagues:

"I’d come up with these creative ideas ... and she would mock me in front of other people about me doing it, like she continues to mock me about doing, if I’ve done any role plays. It just puts you off doing anything creative and also she did it with her own class. Like later on, ... I thought to myself, “you made me feel so stink about doing that and like it was wasting class time and yet you went and did it yourself”.

Cathy (Female)

Connected to the sense of encouraging one another, helping with difficulties and sharing ideas was the importance of feedback from colleagues. For those teachers who received feedback they found it was useful to their development as a teacher. They felt valued because someone was taking a professional interest in their
work. The feedback occurred formally, through an appraisal system or informally, through discussions with individuals or groups of colleagues within the department:

*The previous head of department ... was very, very good at giving me feedback. I mean both, she was appraising me so I got written feedback but just during conversations as well, she’d give me feedback or you know she’d have heard a lesson that I gave or she’d have seen a resource that I made and I was constantly getting very positive feedback.*

**Keryn**

Some teachers reported they had no feedback about their teaching or the feedback was unhelpful. To be helpful to their development as a professional, the formal feedback that occurred through the appraisal system needed to be constructive and the appraiser needed to be engaged and interested in the work of the early career teacher. Cathy was in a situation where this was not the case and she was not happy about the process by which she received feedback:

*He just says, ‘oh you’re doing a great job’ and he’ll walk into my class and walk out and say ‘that was great’ and writes a [report].*

**Cathy**

**Affiliation**

The smallest difference in mean scores was between early career science teachers’ perceptions of the actual department-level environment and that which they would prefer was on scales for Affiliation and Empowerment.

The average item mean score for Affiliation (actual) was 4.24. This was the highest average item mean for all the scales. That is, early career teachers perceived that Affiliation, a sense of belonging and provision of advice and guidance, was already present in their departments. Given that it is already high, this may explain a relatively small difference in mean scores as teachers cannot increase their sense of belonging much more, as it is already perceived as quite high.

For the teachers interviewed a key theme linked to Affiliation was support. For those teachers who reported a collegial atmosphere in the department they talked about a sense of belonging and not creating a competitive and hierarchical department:

*Well we’ve got 11 teachers in our department and we just get on really well with each other. There is no hierarchy, no-one is trying to outdo anyone else or challenge anyone else.*

**Belinda**

Most of the teachers believed their science departments were supportive and this agrees with the questionnaire data. However, two of the teachers, Cathy and Robert, highlighted aspects of their department that were less than supportive and collegial.

**Empowerment**

In contrast to the result for Affiliation, the average item mean score for Empowerment (actual) was 3.27, which is not particularly high. This suggests that teachers perceive relatively low empowerment in their science departments. However, the preferred average item mean score was 3.61. This is only a difference of 0.34. This suggests that whilst Empowerment is not rated highly in science departments it does not appear that the early career teachers want a lot of empowerment and/or are happy with the current level of decision making capacity within their science department.

This was supported by the teachers who were interviewed. The early career teachers were happy for the Head of Department or senior members of staff to make decisions related to the science department and the teaching programme:

*Sometimes you don’t have a lot to say like what’s going to be taught or how you teach it. You have to do what the HOD [Head of Department] tells you to and you just do it. ...I’m quite okay about that because sometimes I’m not that inventive myself and usually they’re quite creative so they usually have quite good ideas so you just do what other people do.*

**Belinda**

Moreover, Robert believed that it was the responsibility of “those in-charge” and who had management roles not to delegate tasks to others. He states strongly:

*If you take the responsibility and you take the money for the responsibility, you should not then pass on your work to other people to do. ... If I take the responsibility and I take the management for that job then I do
the work and I’d take the praise if it’s good or the slap on the back of the hand if it’s bad. The buck stops there and I expect my management to do the same.

Robert (Male)

However, for all the teachers it was important to have some freedom within their classroom, to make decisions about how they taught and to some extent what they taught. Nicola exemplifies this:

As a professional you are there to make those decisions as to what is appropriate and yes I feel I’m left to work the way I want to work which is great.

Nicola (Female)

DISCUSSION

The 53 early career teachers indicated that they would prefer a more favourable level of each DLEQ dimension than they currently perceive occurs in their science departments. That is, less Work Pressure and an increase in the other dimensions. The teachers interviewed provided further insight into the work lives of early career science teachers.

Interestingly, while the 53 teachers preferred an increase in levels of Empowerment it was not rated highly in science departments and they also preferred a departmental work environment that did not allow them much decision making. Studies have shown that schools that provided greater levels of autonomy and allowed teachers to have some influence over school decisions (Ingersoll, 2001; Kim & Loadman, 1994) and influence over disciplinary policies (Weiss, 1999) lead to lower attrition rates.

However, it appears that Empowerment at the department level was not particularly important for early career science teachers and this may reflect the stage they are at in their career. From the interviews, it was however important to have some say about their every day work in the classroom. This was also linked to Resource Adequacy as a perceived lack of resources hampered the teachers’ autonomy within the classroom.

The teachers preferred greater Affiliation and Professional Interest in their departments. From the interview participants it was indicated that a collegial and collaborative environment was desired in which the early career teachers felt emotionally supported but also supported in systemic ways through discipline structures and Resource Adequacy, in particular, a need for an increase in quality classroom materials and ICT resources.

Fullan and Hargreaves (1996) indicate that often a culture of individualism exists within secondary schools rather than strong collaborative practice. Teachers work in isolated ways that fails to encourage teachers to learn from one another and thus take risks and focus on quality teaching (Rosenholtz, 1989). In addition, in isolated environments, little positive feedback is received and teachers engage in more self-reliant behaviour. Consequently, teachers are in a position where they are unable to share the knowledge they have and also unable to receive assistance from others, a situation that ultimately becomes unsatisfying.

To avoid such an untenable situation and improve work environments in the area of collegiality and collaboration more opportunities to discuss professional matters and undertake professional development is required. These opportunities need to occur in a collegial, supportive environment in which teachers’ ideas are welcomed and valued. Departments need to consider systemic and cultural ways in which they can share ideas in a constructive manner. These opportunities might occur as structured episodes within a department meeting. Many of the early career teachers indicated the importance of less time spent on administration and paperwork and the need for more time to be devoted to discussions about teaching and learning.

Unfortunately for Cathy and Robert they were working in unsatisfying environments and were the least positive about their environments. Cathy had found the lack of collegial support and student relationships the most difficult and had decided to leave teaching at the end of the year. Robert also had concerns about a lack of collegiality and support. He felt that he did not fit in with the department and other staff members were privileged. While he still enjoyed teaching his subject and loved working with students he considered the relationships in the science department unsustainable. At the time of the interview, he was searching for another teaching position.

While not necessarily causal, we suggest that early career teachers’ perception of their department has an impact on their career aspirations. If the environment does not support a culture of collaboration and collegiality the early career teacher will decide to leave permanently or move schools. While moving schools may help to retain teachers in the short term, it is unlikely to resolve the underlying issues of retention in the long term.

CONCLUSION

If we are to have work environments that are positive and ones that retain early career teachers in secondary schools we suggest we need to find ways to support teachers in their everyday role by examining the features the teachers have indicated as problematic or supportive. Policy makers, teacher educators and teachers in subject departments need to become engaged in a debate about how to promote a science department culture that
supports the work of early career teachers. This may prove extremely challenging but is worth examining if we are to retain quality teachers in secondary schools. A move that will ultimately benefit the students they teach.

REFERENCES


BECOMING “THE PROVIDER” IDENTITY: PEER DISCOURSES OF MASCULINITIES IN SCHOOL CULTURES

Rebecca Wilson
Curtin University of Technology
Australia

ABSTRACT

The way in which male students construct and enact masculinities continues to be a prominent issue in education. This paper focuses attention on discourses shared by adolescent boys and where masculinities are governed by the approval of peers. Data is derived from elements of a qualitative study that examined a small peer group in a selected Tasmanian school over a three year period using extensive observation and interview. The participants looked towards the future, and how and who they would become. Securing employment was a high priority and they perceived their identities as “providers” for future families, which they believed would result in increased status and power. These students recognised that education was a necessary evil in order to secure employment and the discourses shared around masculinities, identities and peers impact on how they presented as learners and the choices they made about subject selection. Finally, I argue that educators need to be continually mindful that discourses of gender impact in our classrooms and that we need to challenge students to reflect on these understandings, encouraging them to explore new ways of being.

INTRODUCTION

In recent years there has been a proliferation of research that examines how boys construct and enact masculinities in school settings, in an attempt to understand why many boys are under achieving or disengaging from learning (Bleach, 1998a; Bleach 1998b; Buckingham, 2004; Cameron, 1997; Epstein, 1998; Head, 1999; Hickey and Fitzclarence, 2000; Jackson, 2002; Keddie, 2001, 2003, Kehily and Nayak, 1997; Kenway, 1995; Kenway and Fitzclarence, 1997; Mac an Ghaill, 1994; Martin, 2003; Martino, 1999, 2000; Martino and Pallotta-Chiarolli, 2003; Mills and Lingard, 1997, Nilan, 2000; Reay, 2001; Renold, 2001; Warren, 1997). Working from the premise of gender as being socially constructed (Beynon, 2002, Carrigan et al, 1985; Connell, 1987, 1996, 2000; Epstein and Johnson, 1998, Jackson, 1998) and that gender is central to the construction of identities (Connell, 1995; Morgan, 1992, Paetcher 2006a), this paper proposes that there are many ways to be male, that individuals are active agents who make decisions about the masculinities they will employ and how they will project themselves as males. Gender is actively constructed and performed through a process of negotiation and rehearsal (Archer and Yamashita, 2003; Cornwell and Lindisfarne, 1994; Johnson 1997). Morgan (1992) comments:

Do not consider masculinity a characteristic that one brings uniformly to each and every encounter...(rather) gender and masculinity may be understood as part of a presentation of self, something which is negotiated, implicitly or explicitly over a whole range of situations...in short, we should think of ‘doing masculinities’ rather than of ‘being masculine’. (Morgan, 1992, p.46)

In classrooms throughout the world, boys are active agents, searching for meaning and self determining how they will project themselves, making decisions about masculinities they will employ. These “gendered selves” (Renold, 2003; Martino and Pallotta Chiarolli, 2003) are shaped considerably by the perceptions of others (Halberstam, 1996; Paetcher, 2006b). In the school setting it is the audience of peers that are pivotal in determining the discourses of masculinities that individuals engage in, and the images of masculinities and identities that they aspire to. There is a sense of moving towards what they want to become.

This paper will provide further insight into the background of this study, as well as focusing attention on the masculinities the participants aspired to and how these discourses shaped the way in which they choose subjects. Finally, the paper explores what this may mean for educators.

BACKGROUND

The ideas from this paper are drawn from a qualitative study of a small male peer group in a selected school in Tasmania over a three year period from 2003 - 2005, where emphasis was placed on extensive observation and interview. The study used a framework based on three central themes- identity, power and peer relations to shape
and provide focus to the inquiry. In so doing, it sought to find a “third space”, a place where meanings become “fused” and “new horizons” (Taylor, 1989, 1994) emerge in an attempt to understand better the way masculinities impact in the classroom. Seven boys were “purposefully selected” to take part in the study because they were considered “at risk” by school officials for a variety of reasons, including underachieving academically, displaying a variety of social and behavioural issues and not attending school. Throughout this paper, the reader will be introduced to a number of the participants as you hear their voices through the transcripts taken from various interviews and focus groups.

“SOMETHING BIG, TOUGH AND STRONG”

When asked to describe “masculinities” the seven participants described attributes of physical strength, toughness and being large. Howard described masculinity as “big. If you’re big and strong, then you don’t cry”. Stewart used the word “muscular”, while Bob gave extensive detail, concluding “kind of a picture of a big weight lifter, someone tough and strong. Mostly male, real big and muscle, physical strength and well respected”. The subjects drew connections between physical strength and a sense of power which they believed brought respect and status. The images of masculinities the boys identified with, strength, toughness and being larger than life itself, are gained through mastering body and mind, exercising power and displaying courage to overcome mental and physical obstacles. Bob, one of the seven participants described this as having “guts and determination”. Subsequently, the participants believed that displaying these traits would grant them respect, status and power. They would become “somebody”. There is a connection here with Wexler’s (1992) idea of identity and the human drive to become “somebody” in “the public sphere” (p. 115), the continual awareness of the audience of “significant others” and the drive to be recognised and accepted by these “significant others”. For these participants the peer group was a significant audience that shaped and defined the masculinities they displayed. They continually looked for peer approval and worked towards being a “somebody” in the group structure.

“GETTING A JOB”

As educators, we might consider how do these discourses of masculinities that emphasise physical strength, toughness and claiming power impact on their attitudes towards school and education? How do these types of students perceive education and what do they value in their learning?

For many boys in Australia, education is perceived as preparation for future careers, a place Martin (2002) describes “where they learn skills for life, skills they will need for the world of work…” (p. 12). The participants of this research saw future occupations as a way of determining their masculinities. In the first focus group conducted towards the end of Grade 9, the boys readily spoke about the need to undertake studies in certain fields as preparation for their future, and most importantly to be skilled in the work force.

Researcher: School is supposed to be about learning. But what learning do you think is important?
Mick: Your basic…the main studies that you have to do.
Bob: Maths.
Mick: Maths and that.
Researcher: Okay. So you think maths is pretty important?
Stewart: Yeah, in the long run.
Researcher: Okay. So even in the long run, why do you need it in the long run?
Stewart: Because…um…you going to have to deal with numbers in life sometimes.
Bob: Working in the shop and asking customer what’s…
Stewart: Yeah.
Researcher: Yeah, okay. So maths is pretty important. So it is to do for preparation…
Stewart: With getting a job
Bob: Yes
Researcher: …with basically jobs, is that what you think?
Stewart: Yeah.

The boys disclosed over a number of interviews that Maths and English were their least favourite subjects, and yet here, they agreed that Maths should play a significant role in their learning. Stewart suggested that mathematical skills were important, and Bob agreed, to secure employment. Thus schooling is perceived by these boys to be a necessary burden in order to secure a possible future. It is interesting that they did not mention school might help
them develop skills in the present, skills that focus on social interaction, connectedness, initiative and problem solving, for example.

When these boys spoke there was a sense that education was a necessary evil, and the future was a much brighter option. Wexler (1992) claims that “there are students who believe that tomorrow will be ‘bigger and better’ and that when you finish school, they will be able to begin life more broadly and to consider the larger social questions” (p. 63). Stewart mentioned on a number of occasions that “you need to get an education to get a job”, while Jack stated “I’m going to work harder in Grade 10, that’s when the real work starts. You are getting closer to where you want to go. You’ve got to knuckle down and get on with it if you want a good future”, and Mick showed concern that Blair was “throwing his future away” when he showed a pattern of not attending school in 2004.

“PROVIDE. PROVIDE FOR YOUR FAMILY”

The focus on becoming “somebody” implies these boys were working towards the future. Identity, therefore, can be seen as a living project, suggesting movement towards the future, to plan, trail and review, to add element and understanding, a process that is unfolding. When asked about the future, the participants focused on occupations and six of the seven boy’s defined further education (Year 11 and 12) as the next step in their future. These responses raised a number of questions, including how understandings of the future were concerned with career, rather than other life pursuits. At this point in the study, none of the boys mentioned life goals, such as raising a family, acquiring particular resources, developing personal skills or testing aptitudes or capabilities. These boys saw the purpose of school as a preparation for possible careers, and the projection of careers was a way of defining possible futures, and thus identities to aspire to.

The boys often spoke about the future and possible careers, particularly as they moved closer to the end of Grade 10, when students were urged by their teachers and parents to consider their futures. During the first focus group held in October 2004 the subjects entered a discussion about the advantages of being male. They spoke about the ability to secure employment and getting “better jobs” than females, and that careers gave males the opportunities to provide for those they felt responsible for, including partners and children. In the following extract, Bob, Stewart and Mick describe being a “provider” as an important future identity the boys envisaged for themselves.

Mick: Provide. Provide for your family.
Researcher: What does provide for your family mean?
Bob: Like you are the one getting a job…
Stewart: Yeah, givin’ them money.
Bob: …paying the bills.
Researcher: So it’s money, basically. Provide…providing money for your family?
Stewart: Yeah.

The boys shared understanding that providing for future families would place them in positions of power. Benjamin (2001) found a similar discourse amongst the 10 -12 year old boys she studied in the United Kingdom, described as a ‘hunter/provider’ discourse. Similar to this study, she found:

In their interviews, the boys talked about acquiring a wife and children and providing for them materially. These seem to operate as inherent components of masculinity for them. Within this discourse, the boys projected future roles for themselves as earners of a ‘family wage’ through which they would be able to support a wife and children. (Benjamin, 2001, p. 44)

The discourse shared by the participants of this research, was focused on striving for a better life, which they understand was achieved through career and economic stability, one that would bring status and power. The identity of the provider was defined by the participants as economically contributing to the family unit by “givin’ them money” and “paying the bills”. This suggests that through economic means they will maintain power within the families they envisage themselves having in the future. There was a sense that when they achieved these identities as providers, partners and parents they would become complete. The boys believed they had choices in determining who they would become.

For these participants school provides the means to secure an occupation and realise their dreams. Paid work was a way of defining their identities as males and by mid 2004, three of the boys had secured regular casual employment of up to 20 hours per week, as well as attending school, while two of the other boys were employed during their school holidays in a variety of casual jobs. Much of their conversations with each other during this year were about ways of securing work. Being financially independent was highly valued and allowed individuals to acquire status and power. They now had the means to undertake activities they had previously relied on their parents
to support. This permitted the boys the financial means to add to their definition of who they were with the purchase of designer label clothing and drugs and alcohol, and gave them the ability to fund interests such as skateboarding and motor cross riding. Earning an income allowed them economic freedom and autonomy from parents.

Stewart described how he was looking for full time work, and that if he was able to secure employment he would leave school in Grade 9. Securing work was of high importance to him, and would allow him “to do whatever I want. Do my own thing. Be myself. Don’t have to worry ‘bout what my parents think any more or want me to do”. For all of the participants, securing employment and becoming financially independent was a major step in defining who they were, and their future identities as men. They demonstrated an understanding that an education and study was vital in determining future employment and possible future identities.

“IT’S NOT IMPORTANT, NOT VALUED, WOULDN’T HELP YOU GET A JOB”

Educators may take heart that even boys such as these participants see value in education as a preparation for future career pathways, but how do these discourses of masculinities impact on how they make decisions about subjects they choose to study in the later years of high school.

While each of the boys articulated the possibility of being a father as a possible identity for the future, there was a strong discourse amongst the group that studying Child Studies was inappropriate and would bring ridicule and possibly labelling as “a girl”. In the first focus group the boys openly discussed this issue.

Researcher: So is it basically students or boys don’t study child studies at school because they might be labeled gay?
Stewart, Bob: Yeah. (In unison)
Researcher: Teased?
Mick: As a boy, you wouldn’t want others to know you were studying it.
Researcher: Okay. Ah…would there be other reasons?
Mick: It’s not important, not valued, wouldn’t help you get a job, not for what we want to do. It’s for females
Researcher: …for women…women?
Stewart: It’s more to do with women. They’re the ones that have to carry the baby around.
Researcher: Okay.
Mick: They’re the ones that have to look after it.
Researcher: Yeah.
Mick: Yeah

These participants de-valued activities and learning they considered to be feminine. While they actively saw a future for themselves as fathers, they saw little value in Child Studies. Students define subjects along gender lines. Studies are seen as either masculine or feminine (Connell, 2000; Epstein and Johnson, 1994; Grant and Sleefer, 1986; Lingard et al., 2002; Mac an Ghaill, 1996). Martino and Pallotta-Chiarolli (2005) further explore this issue of subject selection, claiming “an important component of masculinity is avoidance of what I perceived to be the feminine, so boys in secondary schools may still favour ‘masculine’ subjects as a way of reinforcing their identity as males” (p. 16). They further intimate “the link between these traits and some school subjects could be this: the ‘masculine’ ones are career oriented and concerned with the phenomena and the world of objects, while the ‘feminine’ ones are people oriented, involving expression and exploration of human emotions” (p. 16).

The discourses of masculinities these participants share regulated the subject choices they made. Subjects were chosen because of their value in preparing for suitable careers. For these participants, school was ultimately a necessary journey to acquire future employment. The identities they strive for are positioned in the future, where economic independence brings status, power and respect. The choices they make in the present about school will determine the type of provider they will become.

CONCLUSION

The issues surrounding boys’ education are extensive, and like other researchers I agree there is no single solution to the problem of boys’ underachievement in education (Keddie, 2006, Martino et al, 2004). As educators, we must remain active in continuing to examine and explore all possibilities, to enter a rich dialogue with our students, a place where they feel safe to voice their beliefs, values and to share with us their practices as males.
We might consider more rigorously that our students are actively engaged in discourses of gender through practice and play with “significant others”, particularly their peers, and that this does impact on how they present as students in our classrooms. For many of them, they are focused on the process of “becoming”, and gender is central to this life project. We need to challenge our students on a daily basis to reflect and question these discourses of gender, to expand these understandings and possible ways of being (Alloway et al, 2003; Martin, 2002; Martino, 2000; Martino and Berrill, 2003; Robinson, 2005). Finally, we need to promote a philosophy of education for life, rather than for career only. By engaging boys in particular, in these discussions, we need to remain hopeful that the future identities they project for themselves extend beyond just the identity of “provider”.

REFERENCES


AN INVESTIGATION OF STUDENTS’ ACHIEVEMENT IN BIOLOGY, THEIR ATTITUDES, 
MOTIVATIONAL TRAITS AND SOCIO-PSYCHOLOGICAL INTERACTIONS IN SINGLE-SEX 
SCHOOLS

Bob Chui-Seng Yong
Universiti Brunei Darussalam
Brunei Darussalam

ABSTRACT

Single-sex schools have long been seen as an alternative means of providing equal educational opportunity for boys and girls. As learning is a cultural activity, it is believed that separation of boys and girls into single-sex schools will create school ethos that are vastly diverse in nature. The present paper reports on a study on single-sex education in Brunei Darussalam. In this study, students’ achievement in biology, their attitudes towards biology and their perceptions of socio-psychological interactions in biology classes between boys and girls in single-sex schools were compared. Girls’ achievement in biology was found to be higher than boys in single-sex schools. In terms of attitudes, no significant differences were observed between boys and girls attending such schools. The results of students’ perceptions of classroom learning environment and teachers’ interpersonal behaviour also revealed several significant differences between boys and girls from single-sex schools. The findings demonstrate that single-sex education produces benefits, particularly for girls, compared to their male counterparts.

INTRODUCTION

The preference for, and retention of single-sex schools has been under intense debates in recent years despite its widespread acceptance and implementation in many educational systems. Findings in numerous research studies have provided ample evidence which suggests single-sex schools are in fact beneficial to both boys and girls.

Perhaps the most important benefit of single-sex schools is academic achievement. For example, Kelly (1996) found that girls in single-sex schools achieved better in GCSE than girls in coeducational schools and a similar pattern was reported for boys. Earlier studies by Bauch (1988 cited in LePore and Warren, 1997, p. 490) also made the same observations and reported that students in single-sex schools consistently outperformed students in mixed-sex schools in mathematics, science and reading. Daly and Defty (2004) reported that girls’ achievement in mathematics were slightly higher than girls in mixed schools. Chung (2000) studied students’ achievement in science in Brunei Darussalam and found that students in single-sex schools have higher achievement compared to those in the coeducational schools. In a slightly different setting, Streitmatter (1998) examined a girls-only physics class and a mixed physics class in a coeducational school and found that girls in the single-sex class made substantial gains in both academic achievement and in perceptions of themselves as competent learners of science.

Another benefit of single-sex schools is less polarisation of curriculum subject according to gender stereotype. In a more recent study, Thompson (2003) found that girls who attended all-girls’ high schools are more likely to major in less traditionally female fields of study than girls who attended coed high schools. She reported that more girls chose to major social science, life science, business and management compared to traditional majors like health science, library science and education. In subject preference, Stables (1990) found that single-sex educated boys were much more interested in drama, biology and language than were boys in mixed schools. Conversely, he found physics was better liked by girls in single-sex schools than girls in mixed schools. Similarly, Lawrie and Brown (1992) observed that more girls in single-sex schools chose A-level mathematics and more boys in single-sex schools chose A-level language, subjects which are traditionally taken by more boys and girls in coeducational settings respectively. Colley, Comber and Hargreaves (1994) also found that girls from single-sex schools showed much stronger preference for the male stereotyped subjects of mathematics and science than girls from coeducational schools.

The third advantage of single-sex schools is students’ attitudes towards school subjects. Daly and Defty (2004) found that students attending girl’s schools have more positive attitudes to mathematics than girls attending mixed schools. Lawrie and Brown (1992) reported that girls from single-sex schools have more enjoyment in learning mathematics than their counterparts in coeducational schools. Chung (2000) studied students’ attitudes towards science in Brunei Darussalam and found that students in single-sex schools have more favourable attitudes towards science compared to those in the coeducational schools. Lee and Bryk (1986) and Riordan (1990) stressed
that students in single-sex secondary Catholic schools took more academic oriented courses, scored higher on standardised achievement tests, and had higher educational aspirations.

Another advantage is the absence of gender bias in single-sex schools. There are reports that boys and girls may not get the same educational opportunity when they share the same classroom environment due to differential teacher attention to boys and girls (Beam, Wheldall and Kemp, 2006). Kelly (1988) found that in mixed classes boys received more teacher attention, more criticism and more instruction than girls irrespective of teacher gender, students’ grade level, subject area, ethnic group and socio-economic background. Studies by French and French (1984), Spencer (1982 cited in Jackson and Smith, 2000, p. 410) and Tyack and Hansot (1990) also found that boys received more teacher attention than girls in mixed sex classes.

It is believed that single-sex schools provide a better environment for learning. There will be no interruption of girls by boys in mixed classes (Tyack and Hansot 1990) and no sexual harassment of girls by boys (Hughes and Sandler, 1988; Mahoney, 1985). Riordan (1985 cited in LePore and Warren, 1997, p. 488) suggested that single-sex schools provide fewer nonacademic distractions, fewer problems of control and discipline, and greater display of same-sex academic role models. Jackson and Smith (2000) provide evidence which suggests that single-sex school environments create social/interaction advantages for girls.

In Brunei Darussalam there is an increase interest in single-sex schools because of the Malay Islamic Monarchy (or *Melayu Islam Beraja*) concept which the country strongly upholds. Islamic values and Islamic way of life are integrated into the education system and as a result there is a strong desire to have separate schools for boys and girls. Though the majority of schools are coeducational, there are a few single-sex schools which cater for boys and girls separately. The need to examine further the relative merits and demerits of single-sex schools will give policy makers more insight into this type of school. The paucity of research study in this area in Brunei Darussalam to date provided an added impetus for this study to be undertaken. The purpose of the study is to explore students’ achievement in biology and their attitudes, motivational traits and socio-psychological interactions in biology classed in single-sex schools. More specifically, it attempts to find out if there are significant differences in these variables between single-sex boy and single-sex girl schools. The research questions are as follows:

1. Are there any statistically significant differences in students’ achievement in biology between students in single-sex girl and single-sex boy schools?
2. Are there any statistically significant differences in students’ attitudes towards biology between students in single-sex girl and single-sex boy schools?
3. Are there any statistically significant differences in students’ motivational traits in learning biology between students in single-sex girl and single-sex boy schools?
4. Are there any statistically significant differences in students’ perceptions of classroom learning environment in biology classes between students in single-sex girl and single-sex boy schools?
5. Are there any statistically significant differences in students’ perceptions of teacher interpersonal behaviour in biology classes between students in single-sex girl and single-sex boy schools?

**METHOD**

**Sample**

The sample for this study consisted of 61 boys and 103 girls from two single-sex boy and three single-sex girl schools respectively. They were Form 5 science students who were about to sit for their GCE O-level examinations. The average age of the students was 16.2 years.

**Questionnaire**

The questionnaire consisted of five parts: Part 1 was to find out students’ background such as name of student, sex, age and name of school. Part 2 consisted of 36 items which measured students’ attitudes towards biology and this instrument was adopted from Chung (2000). The items were categorised into six scales, viz., enjoyment of biology, anxiety towards biology, importance of biology, interest in biology, motivation towards biology and confidence in learning biology (Table 1). Each scale has 6 items which students have to respond on a four-point Likert-type format ranging from 1 (strongly disagree) to 4 (strongly agree). Half of the items were written negatively and the other half written positively. The aim was to encourage students to read each item carefully before giving a response. Items that were negatively worded were given a reverse score. Since there were 6 items in each scale, the minimum score of 6
was interpreted as highly negative whilst the maximum score of 24 was considered as highly positive. A score of 15 was taken as neutral in terms of the attitudes of students toward biology.

Table 1

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>Extent to which students enjoy biology lessons.</td>
<td>Learning biology is fun.</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Extent to which students are anxious about biology lessons</td>
<td>I am scared of biology.</td>
</tr>
<tr>
<td>Importance</td>
<td>Extent to which students perceive the importance of biology to everyday life</td>
<td>Biology is especially important to everyday life.</td>
</tr>
<tr>
<td>Interest</td>
<td>Extent to which students are interested in learning biology.</td>
<td>I am interested in learning biology.</td>
</tr>
<tr>
<td>Motivation</td>
<td>Extent to which students are motivated to study biology</td>
<td>I am looking forward to doing more biology.</td>
</tr>
<tr>
<td>Confidence</td>
<td>Extent to which students are confident in doing biology.</td>
<td>I feel confident when doing biology.</td>
</tr>
</tbody>
</table>

Part 3 of the questionnaire aimed to measure students’ motivational traits. This Student Motivation in Biology Questionnaire (SMBQ) was adapted from Poh (2000) who used it to investigate student motivation in learning science at lower secondary level. The questionnaire has 30 items which were categorized into 5 student motivational traits, viz., achiever, curious, conscientious, sociable and value-conscious (Table 2). Each trait has 6 items which students have to respond on a 4-point Likert-type format ranging from 1 (strongly disagree) to 4 (strongly agree). Since there are 6 items in each trait, the minimum score possible is 6 and the maximum score possible is 24, and 15 is taken as the mid point between these two scores. Mean values higher than 15 represent high magnitude of the dimension whilst mean values lower than 15 represent low magnitude of the dimension.

Table 2

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achiever</td>
<td>Feel the need to achieve or succeed.</td>
<td>I like to get good marks in biology, even if I have to work hard.</td>
</tr>
<tr>
<td>Curious</td>
<td>Feel the need to satisfy own curiosity.</td>
<td>In biology class, if I do not understand something, I look up in a book.</td>
</tr>
<tr>
<td>Conscientious</td>
<td>Feel the need to complete the tasks given.</td>
<td>I get worried if I cannot solve a given problem in biology.</td>
</tr>
<tr>
<td>Sociable</td>
<td>Feel the need to get on well with other students in class.</td>
<td>Having friends to discuss is one of the most important things to learn biology at school.</td>
</tr>
<tr>
<td>Value-conscious</td>
<td>Feel the need to have knowledge of biology.</td>
<td>I think I will be able to use what I learn in biology in other subjects.</td>
</tr>
</tbody>
</table>
Table 3  
Scale, Description and Sample Test Items of WIHIC Questionnaire

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student cohesiveness</td>
<td>Extent to which students know, help and are supportive of one another.</td>
<td>I make friends with students in biology class.</td>
</tr>
<tr>
<td>Teacher support</td>
<td>Extent to which the teacher helps, befriends, trusts and is interested in students.</td>
<td>My biology teacher takes personal interest in my studies.</td>
</tr>
<tr>
<td>Involvement</td>
<td>Extent to which students participate actively and attentively in class discussions and activities.</td>
<td>I discuss my ideas with both my teacher and friends in biology.</td>
</tr>
<tr>
<td>Investigation</td>
<td>Extent to which students use skills and processes of inquiry in problem-solving and investigation.</td>
<td>I carry out investigations to test my ideas in biology class.</td>
</tr>
<tr>
<td>Task Orientation</td>
<td>Extent to which students complete their activities and stay on course in the subject matter.</td>
<td>Getting some work done in biology is important to me.</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Extent to which students cooperate with one another and share resources.</td>
<td>I cooperate with other students when doing biology assignments.</td>
</tr>
<tr>
<td>Equity</td>
<td>Extent to which students are treated equally by the teacher.</td>
<td>The biology teacher gives as much attention to my questions as to other students in the class.</td>
</tr>
</tbody>
</table>

Part 4 consisted of 49 items to measure classroom learning environment in biology classes. It used the Questionnaire on What Is Happening in This Class? (WIHIC) which was adapted from Poh (2000) for lower secondary science classes. The items were categorised into 7 scales, viz., student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation and equity. The description and sample item of each scale was presented in Table 3. Some of the original statements were reworded to make them more suitable and clearer for the local students. For example, one statement which read, ‘The teacher goes out of his/her way to help me’ was changed to ‘The biology teacher gives his best to help me.’ In each statement, the word ‘biology’ was added, thus describing and emphasising specifically their biology teacher or biology lessons/classes each time they responded to the statements in the questionnaire. The present version used a five-point response format ranging from never, seldom, sometimes, often and always. Students scored each item from 1 to 5.

Table 4  
Scale, Description and Sample Test Items of QTI

<table>
<thead>
<tr>
<th>Scale</th>
<th>Description</th>
<th>Sample item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>Extent to which teacher provides leadership to the class and holds student attention.</td>
<td>We all listen to this teacher.</td>
</tr>
<tr>
<td>Helpful/friendly</td>
<td>Extent to which the teacher is friendly and helpful towards students.</td>
<td>The teacher is friendly.</td>
</tr>
<tr>
<td>Understanding</td>
<td>Extent to which the teacher shows understanding/concern/care for students.</td>
<td>The teacher trusts us.</td>
</tr>
<tr>
<td>Student responsibility/ freedom</td>
<td>Extent to which students are given opportunities to assume responsibility for their own activities.</td>
<td>The teacher gives us a lot of free time in class.</td>
</tr>
<tr>
<td>Uncertain</td>
<td>Extent to which the teacher exhibits his/her uncertainty.</td>
<td>The teacher isn’t sure.</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>Extent to which the teacher shows unhappiness/dissatisfaction with students.</td>
<td>The teacher is unhappy.</td>
</tr>
<tr>
<td>Admonishing</td>
<td>Extent to which the teacher shows anger/temper/impatience in class.</td>
<td>The teacher gets angry quickly.</td>
</tr>
<tr>
<td>Strict</td>
<td>Extent to which the teacher is strict with and demanding of students.</td>
<td>The teacher is strict.</td>
</tr>
</tbody>
</table>
Part 5 measured teachers’ interpersonal behaviour. It used the *Questionnaire on Teacher Interaction* (QTI) (Wubbels, Brekelmans, den Brok, & van Tartwijk, 2006; Wubbels, Creton, & Hooyman, 1985) which was adapted from Goh and Fraser (1997) for elementary schools in Singapore. In the present study the same questionnaire was used as it was considered suitable for Bruneian students. This simple version has the advantage of enabling the students to understand the items more fully and thus make a better judgment of their teachers’ interpersonal relationship with them. In each item the word ‘biology’ was inserted so that the new statement then read ‘This biology teacher cares about us’, thus describing and emphasising specifically their biology teacher each time they responded to the items in the questionnaire.

The *QTI* adapted from Goh and Fraser (1997) has 48 items which were categorised into 8 teacher behaviour scales, viz., leadership, helpful/friendly, understanding, student responsibility/freedom, uncertain, dissatisfied, admonishing, and strict behaviour. The description and sample item of each scale was presented in Table 4. The present version has a five-point Likert response format ranging from never, seldom, sometimes, often and always, with the aim of giving students a wider choice and more accurate assessment of their teachers’ relationship with them.

The questionnaires were given to the Heads of the Science Department of the schools who distributed them to respective teachers responsible for teaching biology to Form 5 students. Students were asked to respond to the questionnaires at home and to bring them back the next day.

**Biology achievement**

Students’ achievement in biology was determined by the grades they obtained in the Brunei-Cambridge General Certificate of Education Ordinary level (GCE O-level) examinations held in November 2001. The results of which were released in February 2002. In order to investigate the relationship between attitudes and achievement in biology, the grades obtained by students were coded as follows:

<table>
<thead>
<tr>
<th>GCE O-level Grades</th>
<th>Weight Score in this Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distinction (A)</td>
<td>6</td>
</tr>
<tr>
<td>Credit (B)</td>
<td>5</td>
</tr>
<tr>
<td>Credit (C)</td>
<td>4</td>
</tr>
<tr>
<td>Pass (D)</td>
<td>3</td>
</tr>
<tr>
<td>Pass (E)</td>
<td>2</td>
</tr>
<tr>
<td>Fail (U)</td>
<td>1</td>
</tr>
</tbody>
</table>

For analysis of achievement, the grades obtained in GCE O-level results were recorded as weight scores. Thus a higher mean achievement score will represent higher achievement in biology.

**RESULTS AND DISCUSSION**

**Students’ achievement in biology**

Students’ achievement in biology in single-sex girl schools (mean = 3.47) was significantly better than single-sex boy schools (mean = 2.85) (Table 5). The percentage of students who obtained a credit pass (grades A, B and C) in biology was found to be much higher in girls’ schools (53.4%) than boys’ schools (39.4%). This suggests that girls in single-sex schools performed much better in biology than boys in single-sex schools.

<table>
<thead>
<tr>
<th>Achievement of Students in Single-sex Boy (SSB) and Single-sex Girl (SSG) Schools in Biology at O-level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade (%) Mean SD t-value ES</td>
</tr>
<tr>
<td>A</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>SSB</td>
</tr>
<tr>
<td>SSG</td>
</tr>
</tbody>
</table>

Male N = 61; female N = 103; *p<0.05
Table 6

<table>
<thead>
<tr>
<th>Scale</th>
<th>SSB Mean</th>
<th>SSB SD</th>
<th>SSG Mean</th>
<th>SSG SD</th>
<th>t-value</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>19.82</td>
<td>2.74</td>
<td>19.45</td>
<td>2.41</td>
<td>0.89</td>
<td>-</td>
</tr>
<tr>
<td>Anxiety</td>
<td>18.26</td>
<td>2.71</td>
<td>17.77</td>
<td>3.06</td>
<td>1.04</td>
<td>-</td>
</tr>
<tr>
<td>Importance</td>
<td>19.02</td>
<td>2.69</td>
<td>19.51</td>
<td>2.31</td>
<td>-1.25</td>
<td>-</td>
</tr>
<tr>
<td>Interest</td>
<td>18.13</td>
<td>2.70</td>
<td>17.98</td>
<td>2.43</td>
<td>0.37</td>
<td>-</td>
</tr>
<tr>
<td>Motivation</td>
<td>16.82</td>
<td>3.78</td>
<td>16.77</td>
<td>3.26</td>
<td>0.09</td>
<td>-</td>
</tr>
<tr>
<td>Confidence</td>
<td>17.33</td>
<td>2.81</td>
<td>17.13</td>
<td>3.94</td>
<td>0.33</td>
<td>-</td>
</tr>
</tbody>
</table>

**Attitudes towards biology**

The scale mean scores for all the six attitude scales ranged from 16.77 to 19.82 (Table 6). As the scores were slightly higher than 15, it indicated that students’ attitudes towards biology in both types of single-sex schools were moderately positive. More specifically, students in both types of schools have moderately positive attitudes in enjoyment and importance of biology, and slightly lower positive attitudes in anxiety, interest, motivation and confidence in learning biology. There were, however, no significant differences in all six scales. This suggests that students’ attitudes towards biology in both types of single-sex schools were the same.

**Students’ motivation traits in learning biology**

Students’ in both single-sex boy and girl schools were found to exhibit a higher level of curious, conscientious and value-conscious motivational traits and a slightly lower level of achiever and social motivational traits (Table 7). Of the five motivational traits, only one showed significant differences where students in single-sex girl schools exhibited a higher level of value-conscious trait than students in single-sex boy schools. It was also found that students in both types of schools exhibited the same motivational pattern in achiever, curious, conscientious and sociable traits.

Table 7

<table>
<thead>
<tr>
<th>Scale</th>
<th>SSB Mean</th>
<th>SSB SD</th>
<th>SSG Mean</th>
<th>SSG SD</th>
<th>t-value</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achiever</td>
<td>17.59</td>
<td>1.94</td>
<td>17.69</td>
<td>1.85</td>
<td>-0.32</td>
<td>-</td>
</tr>
<tr>
<td>Curious</td>
<td>18.77</td>
<td>2.33</td>
<td>18.27</td>
<td>2.40</td>
<td>1.30</td>
<td>-</td>
</tr>
<tr>
<td>Conscientious</td>
<td>18.08</td>
<td>2.42</td>
<td>18.45</td>
<td>2.40</td>
<td>-0.94</td>
<td>-</td>
</tr>
<tr>
<td>Social</td>
<td>17.61</td>
<td>2.20</td>
<td>17.46</td>
<td>1.98</td>
<td>0.45</td>
<td>-</td>
</tr>
<tr>
<td>Value-conscious</td>
<td>18.44</td>
<td>2.43</td>
<td>19.27</td>
<td>2.39</td>
<td>-2.13*</td>
<td>0.41</td>
</tr>
</tbody>
</table>

*p<0.05

**Students’ perceptions of classroom learning environment in biology classes**

Table 8 showed scale mean scores obtained ranged from 20.38 to 29.24. This suggests that students in both types of single-sex schools perceived their biology classes as having a high level of student cohesiveness, teacher support, task orientation, cooperation and equity, and a low level of involvement and investigation. This seems to suggest that students perceived their classroom learning environment in biology classes favourably where they often received help from friends and worked cooperatively with one another, teachers are interested in their work and treated them equally, and that they stay focused on their work and consistently completed the tasks given. Results also showed that there were significant differences in one of the seven scales in favour of the girls. Students in all-girls’ schools perceived their teachers to provide more teacher support than their counterparts in all-boys’ schools.

**Students’ perceptions of teachers’ interpersonal behaviour in biology classes**

Students’ perceptions of teacher interpersonal behaviour in biology classes measured by QTI were presented in Table 9. The scale mean scores indicated that students from both school settings perceived their teachers to exhibit a high level of leadership, helpful/friendly, understanding and strict behaviours and a low level of uncertain, dissatisfied and
admonishing behaviours. Both groups of students perceived their teachers to provide a moderately level of student responsibility and freedom in biology classes.

There were also significant differences in the way students perceived their teachers. Students in single-sex girl schools perceived their teachers to be better leaders, more helpful/friendly, more understanding and gave them more responsibility/freedom than students in single-sex boy schools. In contrast, the opposite is true for uncertain, dissatisfied and admonishing behaviours where boy in single-sex schools reported their teachers to exhibit a higher level of these behaviours than girl in single-sex schools. This seems to suggest that girls are better treated by their teachers than boys in single-sex schools. In terms of strict behaviour, the results were comparable for students in both types of school settings.

Table 8
Students’ Perceptions of Classroom Learning Environment in Biology Classes (WHIC) in Single-sex Boy (SSB) and Single-sex Girl (SSG) Schools

<table>
<thead>
<tr>
<th></th>
<th>SSB Mean</th>
<th>SSB SD</th>
<th>SSG Mean</th>
<th>SSG SD</th>
<th>t-value</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student cohesiveness</td>
<td>28.56</td>
<td>3.69</td>
<td>29.24</td>
<td>3.46</td>
<td>-1.20</td>
<td>-</td>
</tr>
<tr>
<td>Teacher support</td>
<td>26.26</td>
<td>4.17</td>
<td>29.64</td>
<td>3.64</td>
<td>-5.44***</td>
<td>0.87</td>
</tr>
<tr>
<td>Involvement</td>
<td>20.38</td>
<td>4.29</td>
<td>20.73</td>
<td>4.96</td>
<td>-0.46</td>
<td>-</td>
</tr>
<tr>
<td>Investigation</td>
<td>20.75</td>
<td>4.66</td>
<td>21.13</td>
<td>4.36</td>
<td>-0.51</td>
<td>-</td>
</tr>
<tr>
<td>Task orientation</td>
<td>26.02</td>
<td>4.27</td>
<td>26.90</td>
<td>4.32</td>
<td>-1.28</td>
<td>-</td>
</tr>
<tr>
<td>Cooperation</td>
<td>26.08</td>
<td>3.91</td>
<td>26.26</td>
<td>4.20</td>
<td>-0.27</td>
<td>-</td>
</tr>
<tr>
<td>Equity</td>
<td>26.59</td>
<td>4.71</td>
<td>27.06</td>
<td>4.38</td>
<td>-0.64</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 9
Students’ Perceptions of Teachers’ Interpersonal Behaviours in Biology Classes (QTI) in Single-sex Boy (SSB) and Single-sex Girl (SSG) Schools

<table>
<thead>
<tr>
<th></th>
<th>SSB Mean</th>
<th>SSB SD</th>
<th>SSG Mean</th>
<th>SSG SD</th>
<th>t-value</th>
<th>ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leadership</td>
<td>24.11</td>
<td>3.40</td>
<td>25.33</td>
<td>2.61</td>
<td>-2.57**</td>
<td>0.41</td>
</tr>
<tr>
<td>Helpful/friendly</td>
<td>24.41</td>
<td>4.01</td>
<td>26.12</td>
<td>2.74</td>
<td>-3.23**</td>
<td>0.51</td>
</tr>
<tr>
<td>Understanding</td>
<td>21.75</td>
<td>4.44</td>
<td>24.88</td>
<td>3.23</td>
<td>-5.20***</td>
<td>0.82</td>
</tr>
<tr>
<td>Student responsibility/ freedom</td>
<td>15.93</td>
<td>3.48</td>
<td>17.17</td>
<td>3.74</td>
<td>-2.10*</td>
<td>0.34</td>
</tr>
<tr>
<td>Uncertain</td>
<td>10.92</td>
<td>3.39</td>
<td>9.13</td>
<td>2.64</td>
<td>3.77***</td>
<td>0.59</td>
</tr>
<tr>
<td>Dissatisfied</td>
<td>11.67</td>
<td>3.39</td>
<td>9.27</td>
<td>2.92</td>
<td>4.79***</td>
<td>0.76</td>
</tr>
<tr>
<td>Admonishing</td>
<td>12.34</td>
<td>4.25</td>
<td>8.84</td>
<td>2.79</td>
<td>6.36***</td>
<td>0.99</td>
</tr>
<tr>
<td>Strict</td>
<td>17.77</td>
<td>3.17</td>
<td>18.75</td>
<td>3.16</td>
<td>-1.91</td>
<td>-</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; ***p<0.001

CONCLUSION

Findings of the present study showed there was a significant difference in achievement between girls and boys where girls in single-sex schools performed better in biology than boys in single-sex schools. The results show 59.4% of girls obtained a credit pass in biology compared to 39.4% of boys. In terms of attitudes towards biology, the attitude scales revealed no significant sex-differences; attitudes of both girls and boys from single-sex schools were found to be comparable and moderately positive. The present findings did not concur with those reported by Stables (1990) which showed single-sex-educated boys have more positive attitudes than single-sex-educated girls to biology.

The results also showed students in both types of single-sex schools exhibited the same motivational pattern in achiever, curious, conscientious and sociable traits. However, significant differences were observed in value-conscious motivational trait where students in single-sex girl schools exhibited a higher level of value-conscious trait than students in single-sex boy schools. In his earlier study, Yong (2006a) found that value-conscious motivational trait was positively associated with achievement in biology and it seemed that girls in single-sex schools leaned strongly towards this motivational pattern may well explain the higher achievement in biology at O-level compared to their male counterparts in single-sex boy schools.

The study also showed students in both types of single-sex schools perceived their classroom learning environment in biology classes favourably where there is a high level of student cohesiveness, teacher support, task
orientation, cooperation and equity. Moreover, there was a significant sex-difference in teacher support; students in single-sex girl schools perceived their teachers to provide more teacher support than their male counterparts in single-sex boy schools. This illustrates that girls perceived their biology teachers to be more friendly, more supportive and more interested in their studies than boys. Similarly, Younger and Warrington (1996) also reported that there was more positive teacher-support for learning of girls than for learning of boys in explaining the better achievement of girls in the GCSE examinations.

In terms of teacher interpersonal behaviour, significant differences were observed in the way students from both single-sex schools perceived their teachers. Students in single-sex girl schools perceived their teachers to be better leaders, more helpful/friendly, more understanding and gave them more responsibility/freedom whilst students in single-sex boy schools perceived their teachers to be more uncertain, more dissatisfied and more admonishing. This seems to suggest that girls are better treated by their teachers than boys in single-sex schools. A similar pattern can be found in coeducational schools (e.g., Wubbels et al., 2006).

Studies have shown the existence of differential teacher attention to boys and girls in the classroom because of their behaviours (Beaman, Wheldall and Kemp, 2006). Boys were seen by teachers as being more difficult to fit into the regular discipline of schoolwork (Connell, 1989; Macan Ghaill, 1994), more vocal, boisterous, distractible and immature (Younger, Warrington, Williams, 1999) and more disruptive (Beaman, Wheldall and Kemp, 2006). Girls, on the other hand, were seen as being more mature and more easily conformed to the ethos of school (Gipps, 1996), showed more interest and intellectual curiosity in the subject matter being taught (Younger et al. 1999) and have resilient attributes that make them more receptive to the cognitive rigours and demand of school (Yong, 2006b). Given the greater demand for classroom management due to the behaviour pattern of boys that teachers have to deal, it comes as no surprise that boys in single-sex schools perceived their teachers to exhibit more admonishing behaviour.

There is still a place for single-sex education especially in meeting the needs of particular students and in reducing sex discrimination in education. A good example is the recent regulations issued by the U.S. Department of Education allowing broader use of single-sex education in public schools as a means of meeting the needs of students, providing diverse educational background and improving student achievement (Davis, 2006). It is recommended that more studies be carried out in different subjects to generate empirical data on the merits and demerits of single-sex education in this country.

REFERENCES


THE EFFECTS OF RECIPROCAL TEACHING ON THAI HIGH-SCHOOL SCIENCE STUDENTS’ ENGLISH READING COMPREHENSION

Yuwadee Yoosabai
Saegchan Hemchua
Srinakarinwirot University, Thailand

ABSTRACT

This paper reports a study of strategy training for reading comprehension in a Thai high-school English reading classroom. The study aimed to investigate the effects of reciprocal teaching modified from Palincsar and Brown’s (1984) on the English reading comprehension of twelfth grade science students in a Thai high-school classroom. The experimental group was taught by reciprocal teaching while the control group was instructed through skill-based teaching. Reciprocal teaching involves four main reading strategies: predicting, questioning, clarifying, and summarizing. The results indicated that reciprocal teaching had a significantly positive effect on the English reading comprehension of Thai high-school science students. The posttest mean score of the experimental group was significantly higher than that of the control group. Moreover, reciprocal teaching enhanced the reading ability of both proficient and less proficient students. The implications of these results for developing students’ reading comprehension are discussed.

Keywords: reading comprehension, reciprocal teaching, reading strategy, reading instruction, metacognitive awareness

INTRODUCTION

In Thailand, English is taught as a foreign language, and the purpose for learning English is centered on effective communication. To communicate efficiently, learners need four skills: listening, speaking, reading, and writing. Of all the four skills, reading is regarded as the most vital and necessary skill for second language (SL) and foreign language (FL) students both in the classroom context and in an out-of-class environment (Carrell, 1989, and Grabe & Stoller, 2002). However, in or out of the classroom, students do not have much opportunity to develop their English reading abilities. In addition, teachers rarely give much time to develop strong reading abilities since most of the emphasis is on linguistic knowledge such as grammar points and vocabulary (Chandavimol, 1998). Results from previous studies revealed that Thai students’ English reading abilities do not reach a very high level of efficiency. This may result from several causes including the high number of learners in the classrooms, the readers’ limited reading strategies, and the methods of teaching reading comprehension in Thai classrooms (Chandavimol, 1998 & Mejang, 2004).

RECIPROCAL TEACHING AND ITS THEORETICAL FRAMEWORK

Theoretically, reciprocal teaching is based on Vygotsky’s Zone of Proximal Development (1978) and the proleptic model of teaching (Wood, Bruner, & Ross, 1976, as cited in Manning & Payne, 1996). According to Vygotsky’s concept, children can develop their learning to reach the actual developmental level by independent problem solving, and the level of potential development can be achieved under adult guidance or expert scaffolding, and in collaboration with more capable peers. That is, learners can be encouraged to learn from a lower to a higher level of proficiency if they are supported and provided with appropriate situations or conditions in which they become involved and interact. For language teachers, it is then necessary to provide their learners with scaffolding and tools, including effective intervention and language learning strategies, and then remove the scaffold part by part until the students are able to use those tools and the scaffolding on their own.

The goal of reciprocal teaching is to improve the specific strategies that students apply when reading new texts (Auerbach & Paxton, 1997; Carrell, 1989; Carrell, Pharis & Liberto, 1989; Cotterall, 1990; Palincsar & Brown, 1984; and Palincsar & David, 1990). According to Palincsar and Brown (1984), reciprocal teaching is an instructional approach that can be best characterized by three main features: (a) the scaffolding and explicit instruction by which the teacher guides practice or models comprehension-fostering strategies that can be applied to reading texts, (b) four main reading strategies described as predicting, generating questions, clarifying, and summarizing, and (c) social interaction, which provides opportunities for the learners to improve their cognitive, metacognitive, and affective strategies.

As mentioned above, most studies on the reciprocal teaching approach have been performed in the L1 language classrooms, and only a few studies were carried out in EFL university classrooms in Thailand. However, few
studies on the reciprocal teaching approach have been conducted on EFL high-school learners in Thailand (Soonthornmanee, 2002; Wisaijorn, 2003). It appeared that the reciprocal teaching approach had positive results for all age groups in L1 classrooms and in EFL (mostly university) classrooms. The researcher was interested in adapting Palincsar and Brown’s reciprocal teaching approach to explore the effects of reciprocal teaching on the reading proficiency of Thai high school science students. This study addresses the following research questions:

1. Do the twelfth grade science students in a Thai high-school improve their English reading comprehension after reciprocal teaching?
2. Does reciprocal teaching enhance the English reading ability of proficient and less proficient students?
3. Is the posttest mean score of the experimental group (those participating in the reciprocal teaching) significantly higher than the mean score of the control group (those participating in the skill-based teaching)?

METHOD

Participants

The participants of this study were purposely selected from students in high-schools in Bangkok, Thailand. They were twelfth grade students enrolled in Reading for Further Study (ENG 40201) as an elective course in the second semester of the academic year 2007. They were Thai native speakers of mixed genders and mixed abilities.

Procedures

This study was an experimental study with a mixed method design consisting of the collection and analysis of both quantitative and qualitative data. The participants of this study were composed of 66 twelfth grade students from two classes. They were divided into two groups: an experimental group and a control group. The participants in the experimental group were divided into groups of six. Each group consisted of two proficient readers, two average readers, and two less proficient readers as they had been evaluated according to their final scores of the English Reading Course of the first semester of the academic year 2007.

To collect the quantitative data, the reading section of the National English Entrance Examination was administered to the participants of both groups, before the instruction, as a pretest, to examine the level of their English reading proficiency. Then the experimental group was taught through reciprocal teaching, while the control group was taught through skill-based teaching. After the instruction, a reading posttest was employed to investigate whether the participants improved their reading comprehension and whether the reciprocal instruction enhanced the reading ability of the proficient and less proficient students. In addition, the data obtained from the interviews were triangulated with the data from the reading tests. The data obtained from the two research instruments described below were analyzed both quantitatively and qualitatively in view of the research questions.

INSTRUMENTS

The two research instruments that served to collect the data were the reading comprehension section of the National English Entrance Examination 2004 and interviews.

The National English Entrance Examination 2004

The National English Entrance Examination is made of four parts: situational dialogues (25 items), a cloze letter (10 items), a cloze passage (25 items), and reading comprehension (40 items), for a total of 100 items, for which the test allows 120 minutes. The test is required of the high-school students who apply to study in Thai state-run universities and its purpose is to assess their English ability. In this study, only the reading comprehension section of the National English Entrance Examination 2004 (40 items/50 minutes) was used as both the pretest and posttest to investigate the participants’ reading ability.
**Interviews**

Interviews were performed with the experimental group at the end of the course after the instruction. The participants were asked about the way they used the four strategies of reciprocal teaching (metacognitive reading strategies) when reading the texts, their views on the four main reading strategies in reciprocal teaching, their procedure to complete the tasks, and group working. The interviews were conducted in Thai so that the participants would not have difficulties understanding and answering the questions.

**RESULTS**

The findings were based on the mean scores of the pretest and posttest of both the control group and the experimental group. The mean scores and standard deviations of the participants in the reciprocal teaching on the pretest and posttest are shown in Table 1. Table 2 shows the mean scores and standard deviations of the proficient and less proficient students in reading comprehension ability in the reciprocal teaching group. Table 3 shows the mean scores and standard deviations of the reciprocal and skill-based groups for reading comprehension on the posttest.

In order to investigate whether the participants in the reciprocal teaching group improved their reading ability, the mean score of their results on the pretest and posttest (the English reading comprehension section of the National English Entrance Examination 2004) was calculated using independent t-test to determine whether there was a significant difference before and after the instruction. The results are presented below.

Table 1.
**Mean Scores and Standard Deviations of Students’ Reading Comprehension in the Reciprocal Teaching Method**

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>14.73</td>
<td>17.70</td>
<td>5.783**</td>
</tr>
<tr>
<td>St. Deviation</td>
<td>(5.55)</td>
<td>(5.56)</td>
<td></td>
</tr>
<tr>
<td>(N =30)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 1, the posttest mean score for the participants instructed through the reciprocal teaching method (the experimental group) was significantly different from their pretest mean score at 0.01. This indicates that the students in the reciprocal group actually developed their English reading ability.

Table 2
**Reading Comprehension Mean Scores and Standard Deviations of Proficient and Less Proficient Students in the Reciprocal Teaching Group**

<table>
<thead>
<tr>
<th>Students’ Ability</th>
<th>n</th>
<th>Pretest</th>
<th>Posttest</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less proficient students</td>
<td>10</td>
<td>9.50</td>
<td>13.10</td>
<td>3.959*</td>
</tr>
<tr>
<td>Proficient students</td>
<td>10</td>
<td>21.00</td>
<td>23.80</td>
<td>3.698*</td>
</tr>
</tbody>
</table>

As shown in Table 2, both proficient and less proficient students in the experimental group gained significantly higher mean scores in the posttest than in the pretest. The difference between the two tests stands at 0.05. This indicates that reciprocal teaching enhanced the English reading ability of both proficient and less proficient students.
Table 3  
*Reading Comprehension Mean Scores and Standard Deviations (SD) of Proficient Readers in the Reciprocal and Skill–Based Teaching Groups*

<table>
<thead>
<tr>
<th>Teaching Method</th>
<th>Mean Score</th>
<th>SD</th>
<th>t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reciprocal teaching</td>
<td>17.73</td>
<td>5.620</td>
<td>4.537*</td>
</tr>
<tr>
<td>Skill–based teaching</td>
<td>14.86</td>
<td>4.067</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05

The data in Table 3 indicate that there are significant differences between the posttest mean scores of the experimental group and of the control group, at 0.05. This analysis thus reveals that the students in the reciprocal teaching group (the experimental group) achieved a higher mean score than those in the skill-based teaching group (the control group). As a result, it can be concluded that reciprocal teaching better assisted the students in enhancing their English reading ability than skill-based teaching did.

**Interview Results**

The findings from the interviews support the statistical analysis. Before reading, the participants in the reciprocal group planned to find the main idea of each paragraph, first predicting, then questioning and clarifying, and finally summarizing. Some students mentioned that if the reading text consisted of questions, they would read the questions first in order to grasp the scope of the text. Besides questions, they predicted the text from the title. These are examples of their answers:

- Set the goal of reading such as finding the main idea, clarifying, and drawing a conclusion.
- Check the reading passage. If it includes questions or exercises, read them first and then plan to read the passage to find out the answers.
- Plan to find the main idea of the paragraph. First, predict the text from the title and then, check the prediction by reading for the main idea and then for important details.
- Predict and analyze the title by using background knowledge.

Regarding the while-reading stage, the students indicated that they planned what to do while reading and controlled themselves to reach their plans. All of them knew that finding the main idea was their main purpose for reading each paragraph. Moreover, they knew that to find the main idea, they had to ask questions on the content of the paragraph. So they asked questions related to the main point. When they met with problems related to key words or references, they clarified these. Moreover, they knew how to clarify the unknown words by using contextual clues and word formation. Then, they evaluated their understanding. If they did not understand the text, they reread it. In other words, this all means that they planned, controlled and evaluated themselves while they were reading a text. The following quotes are some examples of the students’ strategies as they were reading the passages:

- While reading, I planned to find out the main idea of the paragraphs by predicting, questioning, clarifying, and summarizing.
- While reading, I read the whole passage to find out the main idea.
- I reread the passage if I didn’t understand it.
- Questioning helps me to understand each paragraph and to find the main idea.
- Clarifying helps me a lot in reading. If I didn’t know the words, I used contextual clues and my own knowledge.
- Summarizing helps me comprehend the text better. I summarized by connecting each main idea.

Regarding the after-reading stage, all the participants agreed that summarizing was important for reading because by doing so, they could see the whole picture of the reading passage. Moreover, they could self-evaluate their understanding. Additionally, when the participants did the exercises without being able to answer the questions, they went back to the text that related to the questions to find out the answers.

As for working in groups, they enjoyed working with their friends and helping each other. They could reflect and share their own ideas. They experienced being a leader as well as a member of the group. Moreover, they could learn from their friends. Some participants pointed out that they prepared themselves for the leader role by thinking of the teacher’ explicit model as well as of those friends who had already acted as leaders. The following are examples of some students’ views.
We could help each other in the group. It was enjoyable and I felt relaxed. We worked together to complete our task. Working in group also helped my weak friends to understand the text.

Working in a group helped me to be a leader and to know what I should do while acting as a leader in my group. I was eager to act like a teacher and prepared myself to help my friends understand the passage. After being a leader, I drew a conclusion or asked my friends to find it in order to evaluate their understanding.

Findings from the interviews suggested that the participants in the reciprocal teaching group developed their metacognitive awareness (planning, monitoring, and evaluating) when they read the passages. After the teacher modeled the procedure of the reciprocal approach, they organized their own thoughts in their cooperative group. Everyone in the group had a chance to be a leader and this reflected directly on their own and others’ performances. The stages of the reciprocal approach guided them into grasping the meaning of the reading passages and improving their reading ability.

As mentioned in the interviews, the participants in the reciprocal teaching group developed their reading skills by consciously using the four main reading strategies. Consequently, most of them improved their reading comprehension.

CONCLUSION AND DISCUSSION

This study investigated if metacognitive training as employed in the reciprocal teaching approach helped EFL science students to better comprehend reading texts. It was found that the EFL science students in the reciprocal teaching group showed higher scores on their posttest than on their pretest. Also, it was found that both proficient and less proficient participants in the reciprocal teaching group enhanced their reading ability. They obtained a significantly higher mean score on the posttest than on the pretest. Moreover, the EFL science students in the reciprocal teaching group showed a greater gain of the posttest mean score than those receiving the skill-based teaching.

According to the findings, it can be concluded that, in this study, reciprocal teaching was an effective reading strategy instruction. These results support the assertion made by Palincsar and Brown (1984) who contend that reciprocal teaching is an effective approach that improves metacognitive awareness and reading comprehension skills. The concept of reciprocal teaching differs from the one supporting skill-based teaching. In reciprocal teaching, the teacher models or provides a direct explanation of the what, how, when, and why related to each strategy, not only mentions what the strategies are. After the students have well practiced, the teacher gradually and slowly passes the leading role and responsibility to the students who complete the tasks in their own cooperative group. In the end, they find themselves able to do the task on their own. This method helps EFL students understand the texts and learn consciously. They learn to plan, monitor or control themselves while reading and to evaluate their planning and understanding. As a result, learners can push themselves from the actual development level to the potential level or learn beyond their actual development level with explicit scaffolding through social interaction.

SUGGESTIONS

Students need time to implement the four main strategies and to get used to the procedure of reciprocal teaching. They need enough practice to help them work on their own and know what strategy to use, and when, how, and why to use it. Furthermore, teachers should provide their students with feedback, guidance, and help while the students are performing the tasks. Following a task, teachers may highlight the problems and misunderstanding that showed up and give the learners suggestions for the next task. Therefore, teachers should be active and attentive listeners while their students are performing their tasks.

In conclusion, this study proposes one reading strategy instruction for improving the reading skills of EFL students. For EFL teachers, this study may serve as a starting point to adapt the procedure of reciprocal teaching to help their students build metacognitive awareness, improve their reading comprehension, and become independent readers.

REFERENCES


ABSTRACT
The purpose of this study is to measure preservice teachers’ perceptions toward MOODLE Courseware. This study gives attention to the variables of internet access and students’ experience with the internet to find whether these variables are significant factors in preservice teachers’ perceptions toward MOODLE Courseware. The instrument collects information about the learners’ perceptions of MOODLE Courseware. The subjects of this study were 95 students who were enrolled in an undergraduate Mathematics Method course. In addition to descriptive analyses, two separate Analyses of Variance (one-way ANOVA) were conducted to answer the research questions in this study. The results of ANOVA showed no significant differences between low, moderate and high access group. However, significant differences were found between years of experience in using the internet. Overall, preservice teachers had positive perceptions toward Web-based MOODLE Courseware. The findings are discussed and recommendations are made based on the results of this study.

Keywords: preservice teachers, MOODLE courseware, mathematics, perception

INTRODUCTION
Internet-based technologies and the www are the basis of online learning environments. With the Internet and computer technology available to most lecturers, educational technology becomes increasingly indispensable in the field of education. Educational technology has played an important role in the innovation of education, providing both lecturers and preservice teachers with more options and flexibility in their teaching practices. E-learning, which is described as the use of ICT to enhance or support teaching and learning in education has become increasingly important in tertiary education (OECD, 2005).

The success of technology infusion in schools depends on training both inservice and preservice teachers (Oh & French 2004). Teacher education programs are among those beginning to adopt online learning as an alternative method of delivery for their students (Pena, 2004). Students’ perceptions toward online learning have been investigated. In a study of perceptions of college students using supplemental web-based instruction, Angulo and Bruce (1999) reported that students found the supplemental web-based instruction was beneficial to their learning. In another study, Wernet, Olliges and Delicath (2000), conducted a survey to investigate students satisfaction and perception toward web-based authoring tool. All students reported that the material posted on the course website was helpful. Similarly, Gay et al. (2005) found that students were generally favourable towards ICT. The more experience a user has with technology, the more he or she tends to accept it (Koohang & Durante, 2003). Naqvi (2006) concluded that students who were exposed to online learning environment had positive attitude toward online learning. Albee (2003) found that college faculty integration of technology directly impacts student teachers’ use of technology and their confidence of technology integration in their instruction. College of education should provide opportunities for pre-service teachers to model effective use of technology and use this technology in a supportive environment (Teng & Allen, 2005). Although there is an increasing use of online learning, there is limited discussion of how students perceive and react to element of e-learning (Smart & Cappel 2006).

BRIEF DESCRIPTION OF MOODLE
MOODLE is a course management system that enables the delivery of online education. Web-based course management tools are the latest wave of technology-based pedagogical tools (Wernet, Olliges & Delicath, 2000). MOODLE stands for Modular Object-Oriented Dynamic Learning Environment. Its design is based on a socio-constructivist pedagogical philosophy that is discovery based and provides for collaborative activities. Developed by Martin Dougiamas in 1999 at Curtin University of Technology in Australia, it has rapidly spread in use online delivery of courses globally. With a complete set of teaching and learning tools for course development, course
delivery, and course management, MOODLE provides a system for student learning and an efficient solution for faculty of all experience levels. It allows educators to design the appearance of course pages, it provides a set of educational tools that can easily be incorporated into any course, and it provides a set of administrative tools that assist the educator in the task of course administration. In contrast to commercial software, it is open source with no licensing costs and uses PHP code. According to the Open Source Initiative website (2005), the major reasons for utilizing open source software include free to distribute and modify, cross-platform compatibility, universal accessibility and active collaboration to improve design. This courseware is also perceived as user friendly and technically easy to manage.

THE PRESENT STUDY: CONTEXT AND PURPOSE

Teachers’ perceptions of technology use affect their attitudes towards using technology in the classroom. However, the number of studies on student perceptions has been a lower priority for researchers (Angulo & Bruce, 1999). This particularly true in the case of Malaysia. Therefore, the purpose of this study is to investigate preservice teachers’ perceptions toward MOODLE Courseware in the context of Faculty of Education, University Kebangsaan Malaysia. Its specific objectives were:

a) To determine the overall perceptions of pre-service teachers toward MOODLE

b) To determine whether there is a statistically significant difference in the students' perceptions toward the Web-based MOODLE Courseware between low, moderate and high access groups

c) To determine whether there is a statistically significant difference among levels of subjects’ experience with the Internet and their perceptions toward the Web-based MOODLE Courseware

RESEARCH QUESTIONS

The research questions were:

(a) What are the perceptions of pre-service teachers toward MOODLE?
(b) Is there any difference in the students' perceptions toward the Web-based MOODLE Courseware between low, moderate and high access groups?
(c) Is there a significant difference among levels of subjects’ experience with the Internet and their perceptions toward the Web-based MOODLE Courseware?

HYPOTHESES OF THE STUDY

The following null hypotheses were tested:

H_01 There is no statistically significant difference in the students' perceptions toward the Web-based MOODLE Courseware between low, moderate and high access groups.
H_02 There is no statistically significant difference among levels of subjects’ experience with the Internet and their perceptions toward the Web-based MOODLE Courseware

RATIONALE FOR THE STUDY

The government of Malaysia encouraged the use of ICT in the education sector. It has invested millions of dollars in primary and secondary schools via a project called Smart School. It is hoped that this paper will inform administrators and educators on how to shape their educational policy regarding the students use of ICT and its resources. Educators will also be informed as to how students perceived technology that they use in the classroom. This study will contribute to the scant body of literature on the perception of pre-service teachers towards web-based course management system, especially MOODLE.
METHODOLOGY

Participants

Participants in this study were 95 students who enrolled in the mathematics method course, which is one of the courses that students should take in their third year of study at the Faculty of Education, Universiti Kebangsaan Malaysia. The participants were undergraduate students majoring in education. There were 20 males and 75 females. These students are currently taking methods courses in preparation for student-teaching next semester. The active participation and interaction with the course content through the web were part of the requirements of completing this course. The course syllabus, content materials, assignments, forum, web resources and tutorials were available online. Students had to get the material, submit assignments, interact with instructor or fellow students and take quizzes. Participation in the study was voluntary as the participants were told that non participant would not affect their grade in the course. The participants were granted confidentiality and were told that the data gathered would only be used for academic purposes.

Instrumentation

A survey instrument was composed of 11 items with five-point Likert scale. The Students’ Perception Questionnaire (SPQ) presents positively worded statements. Responses to each item were based on Likert scale ranging from 1 to 5, where 1 = Strongly Disagree, 2 = Disagree, 3 = Uncertain, 4 = Agree, 5 = Strongly Agree. A higher score indicates more favorable perceptions toward the Web-based MOODLE Courseware. Respondents indicated their first and second option, gender, place of access and amount of use. The SPQ were adopted and modified from the instrument of Naqvi (2006). The maximum score for the SPQ was 55 and the minimum 11. They were designed to gather information about their perceptions of the use of MOODLE Courseware in the Mathematics Method course. The instrument was validated by a panel of university faculty members. The instrument was piloted using 25 pre-service teachers similar to the population of the study. A few changes were made as a result of this pilot study. These changes included changes in the wording and number of items. The reliability coefficient of the instrument was found to be 0.78. According to Fraenkel & Wallen (2005), an alpha value of 0.7 is considered suitable to make possible group inferences that are accurate enough.

Procedure

The researcher gave a briefing over the components of MOODLE and their functions at the beginning of semester. This briefing lasted for 2 hours. The researcher demonstrated to students on how to use the program in order to enhance their understanding. The use of MOODLE was part of the Mathematics Method course. Students had to get material (syllabus, lecture notes), submit assignments, interact with instructor or with each other and take quizzes. At the end of semester, participants were requested to fill the questionnaire.

Data analysis

Data were analyzed using the appropriate statistical methods to answer each research question. The answer "strongly disagree" was coded 1, while the answer "strongly agree" was coded 5. Based on the coding system, the mean and frequency of responses were computed to answer research question 1. For research questions 2 and 3, ANOVA were conducted to examine the variable of internet access and experience.

RESULTS AND DISCUSSION

Demographics

The subjects were 20 males (21.1 percent of total sample) and 75 females (78.9 percent of total sample). Participants’ demographic data showed that more students had access to the internet from university labs, followed by cyber café and personal computer. This suggests that most students make full use of the campus facilities and resources. Results also showed that 40% of pre-service teachers had accessed MOODLE more than 3 times per week. This may suggest a favourable picture that internet usage is common among pre-service teachers. Most of the pre-service teachers had more than 4 years of internet experience.
Table 1
Demographic Data

<table>
<thead>
<tr>
<th>Variables</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>20</td>
<td>21.1</td>
</tr>
<tr>
<td>Female</td>
<td>75</td>
<td>78.9</td>
</tr>
<tr>
<td>Internet Experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 years</td>
<td>33</td>
<td>34.7</td>
</tr>
<tr>
<td>3-4 years</td>
<td>23</td>
<td>24.2</td>
</tr>
<tr>
<td>Over 4 years</td>
<td>39</td>
<td>41.1</td>
</tr>
<tr>
<td>Access per week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-2 times (low)</td>
<td>29</td>
<td>30.5</td>
</tr>
<tr>
<td>3 times (moderate)</td>
<td>28</td>
<td>29.5</td>
</tr>
<tr>
<td>More than 3 times</td>
<td>38</td>
<td>40.0</td>
</tr>
<tr>
<td>(high)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place of Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer lab</td>
<td>64</td>
<td>67.4</td>
</tr>
<tr>
<td>Cyber Cafe</td>
<td>15</td>
<td>15.8</td>
</tr>
<tr>
<td>Personal computer</td>
<td>13</td>
<td>13.7</td>
</tr>
<tr>
<td>others</td>
<td>3</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Descriptive analysis

Table 2 shows the descriptive analyses for the 11 items on the instrument. The mean score for all the items is 3.73.

Table 2
Descriptive Analysis

<table>
<thead>
<tr>
<th>No</th>
<th>Statement</th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOODLE is easy to use</td>
<td>95</td>
<td>3.77</td>
<td>.78</td>
</tr>
<tr>
<td>2</td>
<td>The material provided in MOODLE is easy to locate</td>
<td>95</td>
<td>3.63</td>
<td>.74</td>
</tr>
<tr>
<td>3</td>
<td>Overall layout of MOODLE is easy to follow</td>
<td>95</td>
<td>3.64</td>
<td>.73</td>
</tr>
<tr>
<td>4</td>
<td>I like to participate in forum</td>
<td>95</td>
<td>3.45</td>
<td>.78</td>
</tr>
<tr>
<td>5</td>
<td>I like to see other students feedback</td>
<td>95</td>
<td>3.98</td>
<td>.76</td>
</tr>
<tr>
<td>6</td>
<td>I intend to use MOODLE after I graduated</td>
<td>95</td>
<td>3.58</td>
<td>.77</td>
</tr>
<tr>
<td>7</td>
<td>The experience of using MOODLE is useful to my career as a teacher</td>
<td>95</td>
<td>3.94</td>
<td>.52</td>
</tr>
<tr>
<td>8</td>
<td>I feel that MOODLE is an important part in this course</td>
<td>95</td>
<td>3.91</td>
<td>.64</td>
</tr>
<tr>
<td>9</td>
<td>I can access MOODLE from any location</td>
<td>95</td>
<td>3.62</td>
<td>1.00</td>
</tr>
<tr>
<td>10</td>
<td>Overall, MOODLE helped me understand better the course material</td>
<td>95</td>
<td>3.62</td>
<td>.66</td>
</tr>
<tr>
<td>11</td>
<td>Overall, I like using MOODLE</td>
<td>95</td>
<td>3.92</td>
<td>.56</td>
</tr>
</tbody>
</table>
From Table 2 we can see that respondents rated all of the items as greater than or equal to 3.62. As this result is greater than the midpoint of the rating scale, we can conclude that overall pre-service teachers had positive perceptions toward MOODLE Courseware that were designed for their Web-based learning portion of the course. This study is consistent with Wernet, Olliges and Delicath (2000) and Naqvi (2006) findings.

**ANOVA for access**

Table 3

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>29</td>
<td>3.69</td>
<td>.39</td>
</tr>
<tr>
<td>moderate</td>
<td>28</td>
<td>3.75</td>
<td>.30</td>
</tr>
<tr>
<td>high</td>
<td>38</td>
<td>3.75</td>
<td>.51</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>3.73</td>
<td>.42</td>
</tr>
</tbody>
</table>

Table 4

**Results of ANOVA**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>.065</td>
<td>2</td>
<td>.033</td>
<td>.183</td>
<td>.833</td>
</tr>
<tr>
<td>Within Groups</td>
<td>16.354</td>
<td>92</td>
<td>.178</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16.419</td>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 shows the mean scores for access to the Internet. Table 4 shows the results of ANOVA for access to the internet. A one-way ANOVA was run to test if there was any difference in students’ perceptions between the three access groups. The ANOVA revealed that there was no significant difference (F2,92=0.183, p>0.05). The null hypothesis can therefore be accepted, as there was no significant difference between groups.

**ANOVA for years of experience with the Internet**

Table 5

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 years</td>
<td>33</td>
<td>3.60</td>
<td>0.47</td>
</tr>
<tr>
<td>3-4 years</td>
<td>23</td>
<td>3.66</td>
<td>0.38</td>
</tr>
<tr>
<td>over 4 years</td>
<td>39</td>
<td>3.88</td>
<td>0.34</td>
</tr>
<tr>
<td>Total</td>
<td>95</td>
<td>3.73</td>
<td>0.42</td>
</tr>
</tbody>
</table>

Table 6

**Results of ANOVA**

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>1.601</td>
<td>2</td>
<td>.801</td>
<td>4.971</td>
<td>.009</td>
</tr>
<tr>
<td>Within Groups</td>
<td>14.818</td>
<td>92</td>
<td>.161</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>16.419</td>
<td>94</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 5 shows the mean scores for years of experience with the Internet. Table 6 shows the results of ANOVA for years of experience with the Internet. The results of ANOVA for experience with the Internet indicated that there was a significant difference among levels of subjects’ experience with the Internet and their perceptions toward the Web-based MOODLE Courseware \((F_{2, 92} = 4.971, p < 0.05)\). The null hypothesis can therefore be rejected, as there was a significant difference between groups. Post-hoc contrast testing was used to isolate the differences. Post hoc contrast testing of differences between groups using Scheffe’s test revealed a significant difference between the over 4 years experience and the 1-2 years experience groups \((p < .005)\), and a no significant difference between the 3-4 years experience and the 1-2 years experience groups \((p > 0.05)\). Subjects with more experience with the Internet scored higher. This finding conflicts with Sadik and Reisman (2004), who found that there was no significant relationship between previous internet experience and perception. However, this study is congruent with Koohang and Durante (2003). This study provides initial data for pre-service teachers’ perception toward MOODLE Courseware. As indicated, overall pre-service teachers perception toward the web-based MOODLE courseware was positive. The results provide insight about the implementation of online learning. Another notable finding of this study was that students with experience in using the internet rate it more positive than students with less experience using the internet.

**CONCLUSION**

The findings of this study have indicated that pre-service teachers perception toward MOODLE were very positive. The implication of these results was that pre-service teachers can gain benefits from using MOODLE, particularly if the use is appropriate and systematic. Another implication of this study is that web-based instruction can be used as a method for delivery in mathematics method course as was the case in this study. However, for successful implementation of web-based instruction effort should be made to give faculty members the necessary training, access to the technology, technical and administration support. A limitation of the study was the relatively small sample size which may limit the generalizability of these findings to the population under study. Future research should examine perception among students in different discipline campus wide. In addition, future research could consider other variables such as gender, age and location.

**REFERENCES**


Pena, S. (2004). The Design and Development of an Online, Cased Based Course in a Teacher Preparation Program. *Journal of Interactive Online Learning, 3* (2)

