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The Development of Technological Literacy in
Young Children [Part I]: Background Issues

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Introduction

In the New Zealand Technology Curriculum statement technological literacy is defined as having three strands; technological knowledge and understanding, technological capability, and technology and society. Little is known about the dimensions of technological literacy in practice and the nature of progression in technology, and this is reflected in the on-going debate about assessment in technology.

The author is currently undertaking a three-year longitudinal study of the development of technological capability in twenty-four children during the first three years of their primary education (age 5-7). This initial paper addresses the underlying problematic issues, which impact on the identification and evaluation of technological literacy in young children, and considers the affect of these on research in this field.

The introduction of Technology Education as a compulsory element in the school curriculum has been a major development globally in the last two decades. New Zealand is one of the countries which has introduced a new compulsory Technology Curriculum (Ministry of Education, 1995) for all children from year zero to year ten. This curriculum statement was issued in 1995 and, after a period of time for schools to prepare for the new subject, was fully implemented in 1999. The philosophic underpinning of these new curricula represents a distinctively new direction in education worldwide, and there is little research base as yet for the new discipline (Jones, 1995). In particular, little has been published with regard to the progression of learning in technology by children in their early years of primary schooling.

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The author is currently is carrying out a three year longitudinal study of a class of 24 children, which seeks to investigate the development of technological literacy as defined in the New Zealand Technology Curriculum statement, in children during the first three years of their primary education. The project seeks to find out if common patterns of the growth of technological literacy occur, and to identify any significant affects of prior knowledge, gender, home environment, learning styles, teaching approaches or other factors on this development. It is concerned not only with identifying the developing knowledge and understanding, but also with explaining how and why that development occurs.

However, in order for valid judgements to be made about the development of technological literacy there are a number of problematic areas which need to be explored. Four issues in particular have relevance to the question of identifying progression in technological literacy in the early years of schooling. These are: the nature of technological literacy; the nature of the elements that best represent progression; methods of assessment of learning in technology; the limitations of young children's learning in technology. A discussion of these four issues forms the main body of this paper.

Technological Literacy

Although there is still debate over the nature of technological literacy there appears to be a general consensus in seeing it as necessarily having to be socially situated. The move to the concept of critical technological literacy may be traced back to Pacey (Pacey, 1983). This insistence that technology must be situated within its social context has gathered momentum since then (eg. Barnett, 1995, Pool, 1997, Jenkins, 1998, Prime, 1997).

The New Zealand Technology Curriculum Statement (Ministry of Education) (MOE, 1995) places technological literacy at the very heart of technology education. The aim of technology education is defined as

    . . . to enable students to achieve technological literacy through

the development of: Technological knowledge and understanding;
Technological capability; and Understanding and awareness of the
relationship between technology and society (Ministry of Education,
1995: 8).

This definition, which has been adopted by the author as the starting point for his research
with the children (while identifying the three components which make up technological
literacy), offers little direction as to what these essential knowledges, skills,
understandings and capabilities might be. The Achievement Objective's eight levels of
progression in the curriculum statement offer little guidance to teachers in this matter
(MOE, 1995, end papers).

Progression

The question as to what progression in technology education might consist of, and how it
might be identified and documented, has been debated widely in the last decade. One of
the earliest attempts to define progression was made by Richard Kimbell (1994a). He
makes the point that any discussion of progression must relate to some agreed suitable
goal towards which progress is being made. Technological capability requires both the
acquisition of knowledge and skills, and the ability to make use of both to produce an
appropriate solution to the problem in hand. Kimbell argues that the basic nature of
technological capability is no different at age six or age sixteen, it is only the
sophistication of the technological practice which is different. Progression in technology
education therefore '. . . must mean broadening and deepening the issues being identified
. . .' (Kimbell, 1994a: 70). Progression therefore can be seen as moving from limited
performance to enriched performance. One consequence of this is that progression of
technological capability cannot be captured in 'can do' assessment statements, the
implications of which are explored in the section on assessment.

The problem of identifying progression in technology has also been addressed by
Solomon and Hall (Solomon & Hall, 1996). Based on an examination of the results of

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cognitive psychology, they reject Kimbell's concept of a non-linear pathway of progression. They see evaluation of children's developing spatial and communication skills as the key to identifying progression, and believe that a ladder of skills and competencies can be identified, which would enable teachers to accelerate a child's ability to be technologically creative. In their eyes the key need is sufficient longitudinal research to identify and document this ladder of skills and competencies.

Robert McCormick has also addressed the nature of learning in technology on a number of occasions (eg. McCormick, 1997a, McCormick, 1999). He rejects both notions of technological capability, those that focus on process, and those that focus on content. For McCormick procedural knowledge and conceptual knowledge are intimately interwoven and highly contextualised in successful technological capability. He sees that 'this makes defining a knowledge base, and the search for a unique common set of procedures or concepts, particularly difficult' (McCormick, 1997a: 144).

Kimbell's view of the nature of progression in technological capability would seem to have influenced the direction taken within the New Zealand Technology Curriculum statement. In his paper outlining the steps which led to the publication of the draft curriculum document Jones writes:

> Progression was expressed in terms of increasing number of variables and the complexity of those variables rather than in terms of increasing complexity of solution or skills development. Progression may be more valuably conceptualised as a *broadening and widening the issues identified* as essential to a technological activity (italics mine) (Jones, 1995: 9-10).

There are therefore a number of different things that can progress in technological learning. Knowledge and skills may be very important within a particular unit of work, but not very important outside the unit because they are so context specific. The ability to connect a simple electrical circuit may not be transferable or applicable to other

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technological activities. Technological principles may be generic (eg. functionality) or specific to a particular technological area. There is a need to focus on the generic principles, and not on specific knowledge and skills, if valid judgements about technological capability and progression are to be made.

One of the major problems is identifying what these generic items might be. There is still a debate about the difference between knowledge, principles and concepts. There are a large number of possible technological principles that might be explored by children, and the technological practice process could also include a number of concepts eg. time management, collaboration, presentation of ideas, identification of problem/need, research skills, creating designs, modification of designs as the process is undertaken, evaluation, discussing ideas with others, problem solving etc. The curriculum statement gives a range of statements as to what children might do at level one eg. 'ask questions' (MOE, 1995: 32), but gives no indication as to the cognitive level expected of such questioning.

Assessment

Assessment in technology has been recognised as a major problematic area from its introduction in England in the 1980s (Kimbell, 1997, Kimbell, Stables, Wheeler, Wosniak, & Kelly, 1991).

The importance of formative assessment and feedback in classroom assessment has been well documented (eg. Black & Atkin, 1996, Black & Wiliam, 1998). For feedback to be effective both the learner and the teacher must be aware of the gap between the learners current knowledge, and the desired learning goal or outcome. With regard to technology a major problem is the widespread lack of knowledge of the nature of technological practice by classroom teachers, which leads to the assessment of managerial and social skills, rather than technological capability (Jones & Moreland, 2000, Moreland, Jones, & Chambers, 2000). This lack of understanding of the nature of, and interconnection between, procedural and conceptual knowledge (McCormick, 1997b) is often exacerbated

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by misunderstandings of the nature of 'the' design process and technological problem solving (Hennessy & Murphy, 1999, Murphy & McCormick, 1997). Other factors which have been identified as affecting children's performance in technology include the nature of the task (Kimbell, 1994b, Kimbell, Stables, & Green, 1996) and a lack of teacher scaffolding to enable transfer of knowledge from other disciplines and contexts to the particular need the child is addressing (Johnson, 1997, Layton, 1991, McCormick, 1997a).

Currently two Ministry of Education funded research projects are investigating assessment in technology education in New Zealand, with the purpose of developing a Technology Assessment Framework, that will overcome the problems discussed above. The findings of these two research projects ('Technology Education Assessment – Lower Secondary' and 'Learning in Technology Education (Assessment)') are being used by the author in his research.

Young children's learning in technology

There are also a number of areas of debate regarding the nature and role of design in young children's technological practice, and the level of competency that might be expected from them. The belief that young children can use drawing as a means of modelling and developing ideas, which was strongly held in the late 1980's, has been challenged and it has been suggested that this may represent an inappropriate paradigm of secondary technology being transferred to the primary sector (Stables, 1997). Indeed, it has been suggested that the whole concept of design espoused in the school system may be an artificial construct, with tenuous and problematic links to reality (Welch, Barlex, & Lim, 2000).

There are a number of points raised by critics about the emphasis on drawing in a 'design, make, and appraise' technological unit. It has been suggested that the view that many teachers have of technology, as a linear process, flies in the face of the reality of how children actually work (Fleer, 2000, Rogers & Wallace, 2000). There are a number of

studies which show there is a weak link between design and making, and that children don't refer to their drawings when modelling (Anning, 1993, Anning, 1997, Rogers & Wallace, 2000, Welch et al., 2000). For young children it may be that thinking and designing occurs most effectively orally and mentally, and that there is no need to for them to draw the design they have created in these ways. Sketching is not a method by which children explore a problem, and discussion between children plays a major role in clarifying problems (Welch et al., 2000). For most young children what they produce in the design phase is seen as only one possible solution, the model they make later is yet another and (in their eyes) more significant solution (Hope, 2000).

The attitudes and teaching methods of teachers are also seen as factors that limit the usefulness of drawing and designing for young children. For many teachers drawing is seen as minor method of communication, and is given little emphasis in their general classroom programme (Anning, 1997). As a result children lack understanding of the purpose of design and necessary drawing skills (Rogers & Wallace, 2000). They can find it difficult to draw oblique lines and acute angles in representing solid shapes and structures, and are often asked to design without knowledge of available materials and their properties (Anning, 1997). As a result their designs may often exceed the technical skills of the children, or the limitations of the materials available to them (Fleer, 2000).

However some recent researchers have suggested that children's drawing skills may be more fluid and adaptable than has been previously thought. With the correct modelling by teachers, and exposure to examples of the various drawing genres used for designing, young children may be very capable of drawing designs and using them as reference points in their making activities (Fleer, 1993, Fleer, 2000, Hope, 2000). Anning (Anning, 1997) believes that at the moment drawing is 'caught, not taught' in most classrooms and she stresses the importance of teacher modelling a range of different types of drawing methods. There is some evidence that where the activity is clearly structured and modelled children can use designs for making. Another method of overcoming the lack of

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relationship between children's designs and their making activity may be to use sketching for pre-design ideas and drawing for post-making recording (Anning, 1997).

Technology in the adult world is generally a collaborative process and to model this in the classroom requires the children to work in groups for a significant amount of time. However, group work is more difficult to put into operation with young children, especially with boys, and this presents a range of classroom management challenges (Stables, 1997). It has been suggested that group work may disadvantage some children when working with more assertive peers and that group composition may have a significant influence on individual performance (Claire, 1992, Riggs, 1994). Stables has suggested that working cooperatively and sharing ideas may inhibit individual creativity (Stables, 1997). There is also evidence to suggest that girls are clearly losers when in a minority in a mixed gender group (Claire, 1992).

A discussion of possible factors that may enhance the learning of young children in technology education

Although technology education is a new subject without a large research base and a well-established culture of classroom practice, the literature does indicate a range of factors that appear to influence children's achievement in technology education.

Some of these are related to the abilities and experiences of the individual child. Children's ability to use language to clarify and explain their ideas has a marked impact in their ability to design and problem solve (Medway, 1994). Another key factor seems to be their ability to visualise three-dimensional shapes (Anning, 1997). Children's own physical skills constrain their ability to transform their ideas into concrete reality (Fleer, 2000), and the richness of their experiences prior to entering school have been identified as another influencing factor (Stables, 1997).

The nature of their classroom experience and the teaching they encounter also affect the technological progression of young children. Among the factors which have been identified in this sphere are the chance to explore materials /tools / equipment/ fixing

methods and the range of materials available to them, the method of evaluation, and the opportunity to experience technology within a play/fantasy context (Hope, 2000, Stables, 1997). There appears to be a relationship between richly imaginative play and ability in understanding and design tasks (Fleer, Corra, & Newman, 1996). Teacher explanation and modelling of a range of drawing genres, learning by direct observation or being shown by more expert others and the influence of peers also have a positive impact on the learning of young children (Anning, 1997).

The nature of the tasks they experience are a further influence on this learning. Carr (2000) has identified the affordance, transparency, challenge, flexibility, the accessibility of tools and materials and the task, as being of prime importance in determining the ability of children to undertake technology units in the classroom. Stables (1997) also stresses the importance of challenge and affordance in tasks to extend the understanding of children. Solomon (Solomon, 1998) has suggested that the use of blind variance and selective retention rather than trial and error is a crucial factor. She believes that iterative self-evaluation of work is the key to success. It is also suggested that for creative leaps to occur there needs to be knowledge spaces in the activity.

Conclusion

It is clear that the attitudes of the teacher, his or her pedagogical practices, and the classroom environment and culture, all influence the technological learning of children and that any statement of progression, to have generalisability, will need to isolate and account for these factors.

This paper has identified and discussed a number of problematic areas that need to be taken into account when attempting to identify and document the progression in technological literacy of young children during their first three years of primary schooling. The wide ranging nature of the elements which are seen to make up technological literacy, and the lack of current understanding as to the level of knowledge and capability that one might expect at a particular age, provides a challenge to any researcher in this field. This is further complicated by uncertainties as to the key

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indicators by which developing technological literacy might be measured and the difficulty of effectively measuring learning in technology.   There are also perceived limitations to the ability of young children to undertake technology.

Awareness of all these issues has influenced the data gathering and analysis methods used by the author during the first year of the research project. The pre-school experiences, both in early education and the home, are being explored and evaluated, and two units of technology within the New Entrant classroom have been documented and the learning of the children identified.   (This process and the subsequent findings are the subject of a second paper by the author, in this issue).

Comments welcome
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