The implementation and evaluation of OASIS: a web-based learning and assessment tool for large classes

Chris Smaill
University of Auckland, c.smaill@auckland.ac.nz

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Abstract—This paper describes a Web-based learning and assessment tool developed and implemented over a five-year period. Used predominately with first- and second-year students for skills practice and summative assessment, the tool delivers individualized tasks, marks student responses, supplies students with prompt feedback, and logs student activity. Interviews with instructors indicated that the software had enabled them to manage workloads in spite of rising class sizes and that student learning, based on observation and assessment results, had been enhanced rather than compromised. Student surveys, interviews, focus-group discussions, and informal feedback showed that students found the software easy to use and felt it helped them improve their skills and understanding. Student activity logs provided an insight into student study habits and confirmed the motivating power of assessment.

Index Terms—Computer-assisted learning, electrical engineering education, student feedback, student motivation, Web-based assessment.

I. INTRODUCTION

THE QUALITY of education worldwide is being threatened by growing instructor workloads. In the United Kingdom, 50 years ago, the median lecture size was 19 while the average discussion group size was just four [1]. Such numbers are unthinkable now. In the Department of Electrical and Computer Engineering of the University of Auckland, Auckland, New Zealand, some class sizes exceed 560 at year 1, 250 at year 2, and 180 at year 3.

An effective assessment program is extremely difficult to maintain as class sizes increase. One recent analysis [2] showed that, for classes in excess of 100 students, the instructor devoted more time to preparing and marking just the final examination than to all teaching duties: lecturing, lecture preparation, tutorials, etc. For a year-1 class of 550 in the Department of Electrical and Computer Engineering, the lecturer's time was allocated as follows: 75% to assessment and 25% to lecture preparation and delivery. For a year-2 class of 200, the split was 65%/35%. With most lecturer time devoted to the relatively unexciting task of assessment, its reduction becomes an attractive way of managing workloads. Unfortunately, less assessment is likely to lead to less student effort. One study found that by year 4, only 5% of student time was spent on learning unrelated to assessment [3]. Other studies have shown that the assessment system is the main influence on how students structure their learning, determining both their effort and their focus [4], [5]. Further, less assessment entails less feedback to students, and for large classes feedback may be delayed significantly. The importance of prompt feedback is well established [6]–[8]. One landmark study concluded that "formative assessment is an essential component of classroom work . . . . We know of no other way of raising standards for which such a strong *prima facie* case can be made" [9]. Overall, the research literature makes an unassailable case for providing students with regular assessment and prompt feedback.

As instructor workloads soar, computers are increasingly being used to free instructors from the drudgery of assessment. While initial setup times are higher for computer-based assessment (CBA), long-term gains can be significant. The University of Luton, Bedfordshire, U.K., introduced computer-based examinations and immediately noted an average saving in academic staff time by 50%. Subsequent updates produced a further 50% saving [10]. With the widespread adoption of home computers, CBA, and the Web, instructors can now offer students considerable opportunities for skill-building exercises, formative assessment, and prompt feedback. Students appreciate the opportunity to practice and learn from their mistakes without penalty or loss of face [11], [12].

II. CBA IN THE ENGINEERING FACULTY AT THE UNIVERSITY OF AUCKLAND

The Department of Electrical and Computer Engineering saw CBA as providing a way to maintain educational standards in spite of increasing workloads. Like a number of other departments, this department sought a homegrown solution [13], partly because of cost and partly because of some noted shortcomings in commercial products. For example, one commercial package reportedly recorded only students' total marks for tests, not data for individual questions. It also summarily logged out students who had used up their time without warning and without recording their answers [14]. Question Mark, "a popular shell in the U.K." [13], if used to process more than 100 assessments per day, requires "a separate database server running Microsoft SQL server or Oracle" [15]. This requirement conflicted with the department's need to handle 500 or more users simultaneously on a shared server. Often, commercial packages offered only limiting question formats such as multiple choice [14], [16]. Motivated by some excellent homegrown examples [17]–[19], the software was developed

within the department, and the first version was produced in 2000 [20]. Since 2002, an action research program has regularly improved both the software itself and its implementation as a learning tool.

III. OASIS: ONLINE ASSESSMENT SYSTEM WITH INTEGRATED STUDY

OASIS comprises a large question database and server-side program that delivers questions, marks student responses, provides prompt feedback, and records students' activities. Students need only a computer with Internet access and a standard browser since the Web server carries out all processing. Such easy access makes OASIS well suited to student-centered and large-class learning. Questions are repeatable. Each has 200–300 numerically different variations. Thus, students can practice each question until satisfied that they have mastered the particular skill, situation, or concept. The answers for all numerical variations of each question have been previously calculated and are stored in the question database. Marking is very fast as it generally involves comparison rather than calculation. However, when multipart questions are marked consequentially, then some calculation is involved during marking. The current server, a 1.8-GHz dual Xeon with 1.5-GB RAM, can handle more than 1000 users concurrently without loading problems. Such a large number is possible. One class can be taking a test while another is completing an assignment and other students are practicing questions.

OASIS can be used in practice mode or test mode. In the former, students select their course, then a topic, and then questions from that topic. Fig. 1 shows a typical question from the year-2 course Circuits & Systems. As students practice and improve their skills, they also become familiar with the environment that will be used for tests.

An answer within 1% of the actual answer is deemed correct by default; however, this tolerance can be reset for each question as appropriate. Fig. 2 illustrates the screen displayed when a student submits his or her answers to the question shown in Fig. 1.

In test mode, candidates log on at the same time in a supervised environment. Numerically different versions of the same questions are used, making cheating extremely difficult. Students are marked on the first answer submitted to each question, avoiding issues involving the use of the "back button" on browsers. Students can enter answers to all questions and revise them as desired before finally submitting all their answers. Computerized tests need to offer the same flexibility as traditional written tests in this regard [21].
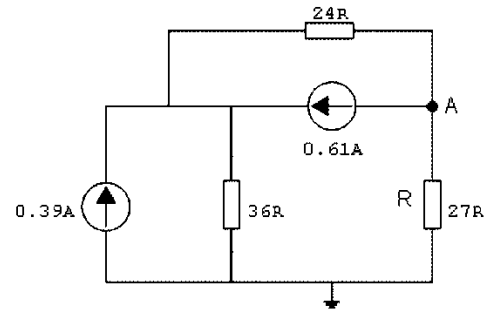
All submissions are recorded—even those entered on the screen but not submitted. This function is of great relief for any student whose computer crashes part way through a test prior to answer submission. The remaining time is displayed throughout the test; when time expires, the student is automatically logged off.

Assignments are similar to tests, except that they are unsupervised, can be taken by students wherever they have Internet access, and have a less stringent time constraint. Typically, assignments must be completed in a single one-hour period

Fig. 1. OASIS question from Circuits & Systems.

Fig. 2. OASIS response to student answer submission.

within a 12-hour period. One hour after logging on, the assignment is closed to the student. However, a student can change computers within the hour, and this feature has been used by students living close to Internet cafes who have been victims of a home–computer crash. Fig. 3 illustrates a six-question assignment.

Traditional assignments are frequently compromised by copying; the individualized assignments of OASIS are much more secure. One student can tell another how to solve a problem but not the actual answer. Instructors often accept this situation because they see it as valid student learning.

All aspects of student performance in both practice and test mode are recorded, including time logged on, time taken, questions attempted, answers submitted, and correct answers to attempted questions. This information can help instructors identify and deal with student learning issues.
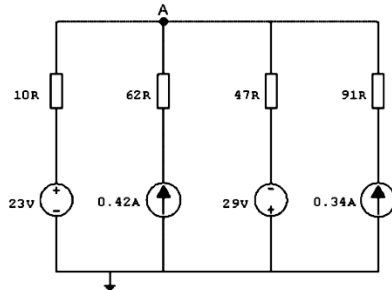
IV. STAFF RESPONSE TO OASIS

Instructors using OASIS provided students with more formative and summative assessment and more feedback than instructors in traditional courses. Feedback was also delivered earlier

Fig. 3.   OASIS assignment comprising six questions.

in the course and more promptly. In fact, both students and instructors received feedback as soon as students started practicing questions on OASIS. Instructors saw CBA as a cost-effective way to maintain effective assessment and high student motivation.

OASIS was also seen as saving considerable instructor time. The following figures for a typical one-hour test are derived from discussion with instructors. Test production is estimated to take about 16 hours for a traditional test and 40 hours for an OASIS test. The latter time is greater because some programming (in MATLAB, for example) is required to generate the sets of answers for each question variation. Marking and mark recording is estimated to take about 22 minutes per student for a traditional test and zero for an OASIS test. Some see the traditional estimates above as rather low [2]. Fig. 4 displays this data graphically. For classes of over 66 students, OASIS saves assessment time. For a typical year-2 course of 200 students, the savings are about 50 hours. For a typical year-1 course of 550 students, the savings are about 180 hours. Greater savings may result if some questions written previously can be reused.

Staff saw OASIS as useful for building and assessing skills. For example, students have become more adept at solving circuits, and this improvement appears to persist from one year to the next. Staff also reported that OASIS was raising student achievement levels. When OASIS practice problems were first provided in a large section of the year-1 course Electrical Engineering Systems, the examination failure rate for that section dropped from 35% to 15%. The examination was traditional in nature, with no significant shift in student ability, and the relevant examination questions were, if anything, more demanding than previously.
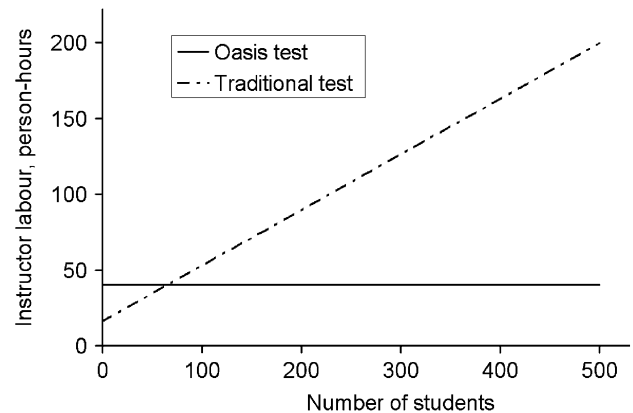

Fig. 4.   Instructor person-hours required for assessment.

One experienced lecturer cautioned that, with OASIS raising student skill levels, examiners needed to ensure they did not unfairly increase the difficulty level of examinations. Users of other Web-based tutorial systems have made similar comments [19].

OASIS can readily deliver questions that are marked right or wrong. Future developments should enable OASIS to handle questions for which some answers are judged better than others, not just right or wrong. However, OASIS is not suited to project or design work, a situation unlikely to change in the future. In these important areas, staff will continue to be faced with a high assessment workload.

For those who manage large classes, skills practice and assessment are key areas of concern. OASIS is useful for these areas. Other areas of concern include delivering study materials, messages, and assessment results to all students promptly, assigning laboratory and tutorial streams, and hosting discussion

TABLE I
STUDENT EVALUATION RESULTS FOR OASIS (KEY: SD—STRONGLY DISAGREE, D—DISAGREE, N—NEUTRAL, A: AGREE; SA: STRONGLY AGREE)

Item	SD (%)	D (%)	N (%)	A (%)	SA (%)
OASIS is easy to use	0	2	6	46	43
I often use OASIS	2	13	35	35	14
OASIS helped improve my skill level	0	5	14	46	34
I am more confident about my learning after using OASIS	0	4	13	54	27
The problems provided in OASIS helped me understand the course material better	0	2	18	50	26
OASIS helps me to prepare for the assessments	1	4	11	50	33
I come to campus less often because of OASIS	15	34	30	8	2
I like the instant performance feedback using OASIS	1	1	14	40	42
I prefer to do problems from the text rather than OASIS problems	6	25	46	14	6
It would be a good idea to have OASIS in other courses	2	2	13	38	40

forums or "frequently asked questions" pages. Software packages are also frequently employed to assist in these areas and further raise educational standards [22]–[24].

V. STUDENT RESPONSE TO OASIS

Students have been surveyed about OASIS in two courses since 2002: the year-1 course Electrical Engineering Systems, compulsory for all engineering students at the University of Auckland and taken in 2004 by about 560 students; and the year-2 course Circuits & Systems, compulsory for all students pursuing electrical and electronic engineering or computer systems engineering and taken in 2004 by about 200 students. Table I shows the results of the 2004 survey of Circuits & Systems. The results are typical. Very similar results were obtained in other years and in other courses. A total of 125 representative students completed the survey, rating ten statements on a five-point scale, ranging from *strongly agree* to *strongly disagree*.

The survey results are encouraging. Most students (89%) found OASIS easy to use, while only 2% did not. The instant feedback was appreciated, with 82% agreeing or strongly agreeing with the statement "I like the instant performance feedback using OASIS." Furthermore, 79% agreed or strongly agreed with the statement "OASIS helped improve my skill level," while 83% agreed or strongly agreed with the statement "OASIS helps me prepare for the assessments." This latter figure was gratifying; since only 10% of the course assessment was by OASIS, the remaining 90% of assessment being traditional (pen and paper).

High usage rates have been recorded in all courses that provide OASIS practice opportunities. When OASIS was first used in the year-1 course Electrical Engineering Systems, the average student submitted answers to 100 questions even though OASIS was not used for assessment that year but was provided for practice only with tutorial and textbook questions. All surveys carried out to date show that students prefer OASIS
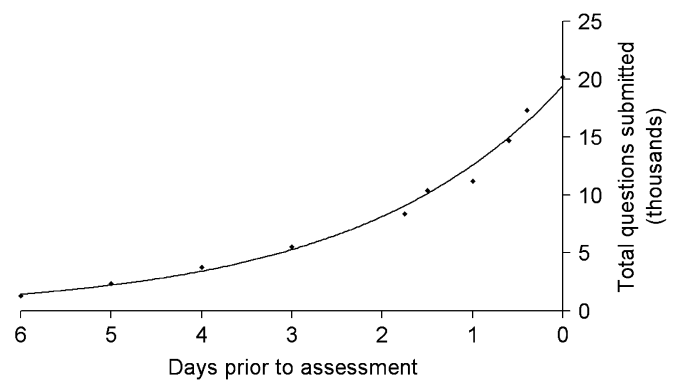
Fig. 5. Year-1 student activity prior to an assessment.

questions to textbook questions and that about 80% of students want OASIS in more courses. When students were asked "What changes or improvements would you suggest for OASIS?" the most common reply was that OASIS should cover more topics.

The data collected automatically by OASIS on student practice patterns are most illuminating. The marked increase in student activity before tests and examinations is weighty evidence for the motivating power of assessments. While many academicians are used to such behavior, without a data-collection device such as OASIS, this behavior is extremely hard to quantify. Fig. 5 shows the total number of questions submitted by students taking the year-1 course Electrical Engineering Systems as they near an assessment. An exponential curve has been fitted to the data.

About 90% of student practice activity for this assessment occurred in the five days before the assessment, with a full 50% taking place in the last 36 hours (8 p.m. on Saturday to 8 a.m. on Monday). Ultimately, the average student submitted answers to about 40 questions. This student effort was largely motivated by an online assignment that required no supervision and no marking and was worth only 5% of the final grade for the course. Comparable student behavior is also observed

prior to similar year-2 online assignments worth only 2% of the final grade.

To date, over 40 students have been interviewed on a one-to-one basis while others have taken part in group discussions. All interviews and discussions were audiotaped and transcribed. The students involved were not entirely representative of the population because several students who were invited for interviews did not respond. The interviews and group discussions generally reinforced the survey findings and enabled a deeper exploration of some issues. For example, in one survey, several students wrote that they would prefer worked solutions in the feedback to their answers, not just the right answer. However, in focus-group discussions, the majority advanced two arguments against the provision of worked solutions. First, in real life, as a practicing engineer, one is not provided with model answers or even right answers. Second, if model answers were available, students would be tempted to submit a random answer in order to receive the model answer. Much of the benefit of a practice exercise would be lost if an illustration of the method could be obtained in this way. Instructors were encouraged that students advanced such arguments themselves. Research indicates that no increased educational value is provided in assistance beyond the correct answer [25] and that, in fact, too much feedback can be counterproductive [26].

In another interesting twist, interviewed students commented that they did not want practice questions to be reused as assignment questions. As a result, similar but previously unseen questions are now used in assignments. Reassuringly, implementing this change did not lead to a significant decrease in student marks.

VI. CONCLUSION AND FUTURE DEVELOPMENT

A number of features distinguish OASIS from most other Web-based learning and assessment tools, many of which are based on multiple-choice questions. Although not restricted to multiple-choice questions itself, OASIS is still able to mark questions in real time with no appreciable delay for several hundred concurrent users without making excessive demands on its server. Each question has literally hundreds of numerical versions, allowing great opportunities for repetition, facilitating student skills practice and development, and making assessment more secure against cheating. In tests, features, such as consequential marking for multipart questions and repeat attempts for partial credit, make the assessment process more fair and more student friendly.

The main benefits of the implementation of OASIS in the Department of Electrical and Computer Engineering at the University of Auckland have been described: instructors have been able to manage workloads while maintaining effective teaching and assessment practices; students have been highly motivated, have received regular and timely feedback on their progress, and have lifted their achievement levels. The feedback provided to instructors on student performance and activity has enabled instructors to support at-risk students, to target problem areas, and to improve course delivery in an informed fashion.

The data collected automatically by OASIS and gathered from surveys, interviews, focus-group discussions, and informal communications with both students and instructors constitute an unusually rich resource for educational research. However, analysis of this wealth of data is only in its initial stages. Even so, already clear evidence is available for the motivating power of assessment and for the tendency of students to procrastinate. Further data analysis should enable more informed teaching practices in the department and also add to the body of educational research in the fast-changing area of computer-assisted learning.

The great majority of problems currently delivered by OASIS are numerical, skills-based problems, marked either right or wrong. In the future, it is hoped that problems will be delivered that test understanding and use the principles of fuzzy logic to grade student answers on a finer scale than right/wrong [27]. Further expansion possibilities, such as implementation in high school physics courses, are being explored. However, OASIS is unlikely to greatly reduce the assessment burden in project and design activities.

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Chris R. Smaill received the B.Sc. degree in mathematics and physics, the B.Sc. (hons.) degree in physics, and the B.A. degree in philosophy from the University of Auckland, Auckland, New Zealand, in 1972, 1973, and 1987, respectively, as well as the Teaching Diploma degree from the Auckland College of Education, Auckland, New Zealand, in 1974. He is currently working toward the Ph.D. degree at Curtin University of Technology, Perth, Australia.

He taught physics and mathematics at Rangitoto College, Auckland, New Zealand, until 2001. During this time, he wrote several high school physics texts published by Pearson Education. Since 2002, he has been with the Department of Electrical and Computer Engineering at the University of Auckland. His main research interests include computer-assisted learning and computer-based assessment.