School OASIS: Virtual outreach - facilitating the transition to university study

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***Abstract**: Too few people are choosing engineering careers, and many engineering faculties are attempting to address this problem by reaching out to schools. This paper describes how a home-grown, web-based software tool, already used successfully in university-level engineering courses, is being modified for high-school use. The software package, OASIS, comprises a large question database and server-side program that delivers individualised tasks, marks student responses, supplies prompt feedback, and logs student activity. OASIS can be used for both skills practice and formal assessment. Because the Web server carries out all processing, students need only a computer with internet access and a standard browser, making OASIS well suited to student-centered and distance learning.*

Introduction

In many countries there is a critical need for more people to choose careers in engineering and technology (Genalo, Christensen, & Watkins, 2007; IPENZ, 2007; NAS, 2007; Richards, Hallock, & Schnittka, 2007; Sorby & Schumaker-Chadde, 2007). In particular, IPENZ (The Institution of Professional Engineers New Zealand) has recently stated that New Zealand has a severe shortage of graduate engineers and needs to produce twice as many to match other OECD countries and to meet its own requirements (IPENZ, 2007). However, increasing the number of engineering graduates is extremely difficult since high-school enrollments in mathematics and physics have declined significantly in recent years (NAS, 2007). A search of the NZQA statistics (available at www.nzqa.govt.nz) reveals that the number of students presenting the level-three (year-13) externally-assessed achievement standard “Demonstrate understanding of electrical systems” dropped from 7111 students in 2004 to 5221 students in 2010. The American Society for Engineering Education, reflecting the nation’s anxiety over the situation in the U.S., has established a K-12 Engineering Education Division and hosts a K-12 Center website (available at www.asee.org/k12/index.cfm). The international declines in student numbers are exacerbated by shortages of appropriately-qualified teachers: students of senior physics are by no means guaranteed a teacher who majored in physics. Such students are most likely disadvantaged in terms of both subject skills and inclination to further study.

Many universities fund outreach programs to increase numbers of engineering undergraduates (Cantrell, Pekcan, Itani, & Velasquez-Bryant, 2006; Cunningham, Knight, Carlsen, & Kelly, 2007; DeGrazia, Sullivan, Carlson, & Carlson, 2001; Gattis, Nachtmann, & Youngblood, 2003; Lee, Wu, Liu, & Hsu, 2006; Mooney & Laubach, 2002; Orsak, 2003; Poole, DeGrazia, & Sullivan, 2001; Richards, et al., 2007; Smith & Monk, 2005; Sorby & Schumaker-Chadde, 2007; St Pierre & Christian, 2002). Ideally, such programs should have two positive outcomes: participating students should be both better prepared for and better informed about engineering careers. The University of Auckland’s (UoA’s) Faculty of Engineering does already have outreach programs that involve both visits to schools and visits by school students to the university. However, these programs, without a large funding increase, can only target students from a small number of local schools. Further, some of the outreach endeavours aim simply to interest students in engineering careers rather than up-skill them in relevant pre-cursor subjects. The ideal outreach initiative should: reach all students in all schools nationally, up-skill students appropriately, increase student interest in engineering, and achieve all this in a cost-effective fashion.

In order to maximize return for investment, it was decided that an internet solution was appropriate, in-person visits to schools on a national scale simply being not feasible. It was also decided initially to target just one subject area, physics, and to cover the final three years of high school (in New Zealand these are known as years 11 to 13). Further subject areas may be added later as resources permit. High-school physics was targeted for three reasons. First, physics is a key prerequisite for engineering. Second, high-school students find physics particularly to understand, and are therefore often discouraged from further study. Third, given the shortage of appropriately-qualified teachers, physics is a subject area definitely in need of support.

OASIS (Online Assessment System with Integrated Study)

The Department of Electrical and Computer Engineering (ECE) at the UoA had previously created and implemented a software package, OASIS (Online Assessment System with Integrated Study), which is used on a daily basis by both engineering and physics students for skills practice, and on a regular basis by instructors for formal assessment (Smaill, 2005). The effectiveness of the software implementation had been previously validated by an action-research study (Smaill, 2007). This study showed instructors considered the software enhanced student engagement and learning, while students described OASIS as easy to use and helpful in improving skills and understanding. Given this positive evidence, it was decided to provide high-school students with their own version of OASIS (School OASIS), the dual aims being to improve the physics skills of incoming engineering students and to promote the University's engineering courses. Additionally, since appropriate ethical requirements have been met, the wealth of data collected by School OASIS can be used in judging student-intake quality and for educational research.

The first version of OASIS was written in 2002, in PHP and using a MySQL database. This software package was well-regarded by instructors, who saw it as both reducing their workload and lifting student achievement, and the decision was made to develop it further. Subsequent versions have been written in Python and utilize a PostgreSQL database.

Comprising a large question database and server-side program, OASIS delivers individualised questions to students, marks their responses, provides instant feedback, and records all student activities, including time logged on, time taken, questions attempted, answers submitted, and the correct answers to attempted questions. Because the web server carries out all processing, students need only a computer with internet access and a standard browser, making OASIS well suited to student-centered and distance learning. And, since the software carries out all marking, OASIS can be used to provide prompt, regular feedback through tests and assignments without the workload issues associated with paper-based assessments. This is particularly significant for large classes, where instructors may be reluctant to set regular assessments since the workload involved in marking is too great. For such classes, there is the further problem of the time taken to return results to students: the turnaround time for paper-based assessments may be two or three weeks, whereas for online assessment, such as that performed by OASIS, it is instant. Given the overwhelming support in the research literature for the motivating power of assessment (Black & Wiliam, 1998; Innis, 1996; Miller & Parlett, 1974; Snyder, 1971) and for the importance of prompt feedback (Freilich, 1987; Gibbs, 1999; Mehta & Schlecht, 1998), these are critical considerations for all instructors.

The record of student activities maintained by OASIS enables instructors to gauge progress and skills at both course and individual level. Instructors can identify at-risk students and take timely remedial action. Instructors can also identify questions that students find difficult and then address these questions in their teaching.

Students are encouraged to practise OASIS questions from day one. In this way they can improve their skills and understanding and receive timely feedback on their progress. Each numerical question has 200 to 300 different variations, so students can practise each question until satisfied they have mastered the particular skill, situation, or concept. As students practice and improve their skills, they also become familiar with the environment that will be used for assessments.

School OASIS: question bank

Most of the existing OASIS questions were written for university physics and engineering courses and are not suitable for high-school use. New questions were needed. To this end, an experienced high-school teacher was employed two days a week through 2010 and 2011 to write literally hundreds of questions, sufficient to cover all externally-assessed achievement standards in the final three years (years 11 to 13) of high-school physics (by way of example, for year-13 physics, there are four externally-assessed achievement standards: "Demonstrate understanding of wave systems", "Demonstrate understanding of mechanical systems", "Demonstrate understanding of atoms, photons and nuclei", and "Demonstrate understanding of electrical systems". The questions are designed to appeal to all students and allow them to monitor their academic progress whether they are struggling to pass or aiming for excellence. As well as working on the School OASIS project, the question author / school teacher also advises high-school science teachers two days a week and teaches high-school physics one day a week. Thus he is ideally placed to develop, promote and receive feedback about School OASIS. This in-person promotion has, in the main, been restricted to the greater Auckland area though some nationwide promotion via cluster-group meetings and the NZIP conference has also taken place. So far, feedback from both teachers and students has been most positive. By the end of 2011 the question bank will be well stocked and School OASIS will have been widely promoted.

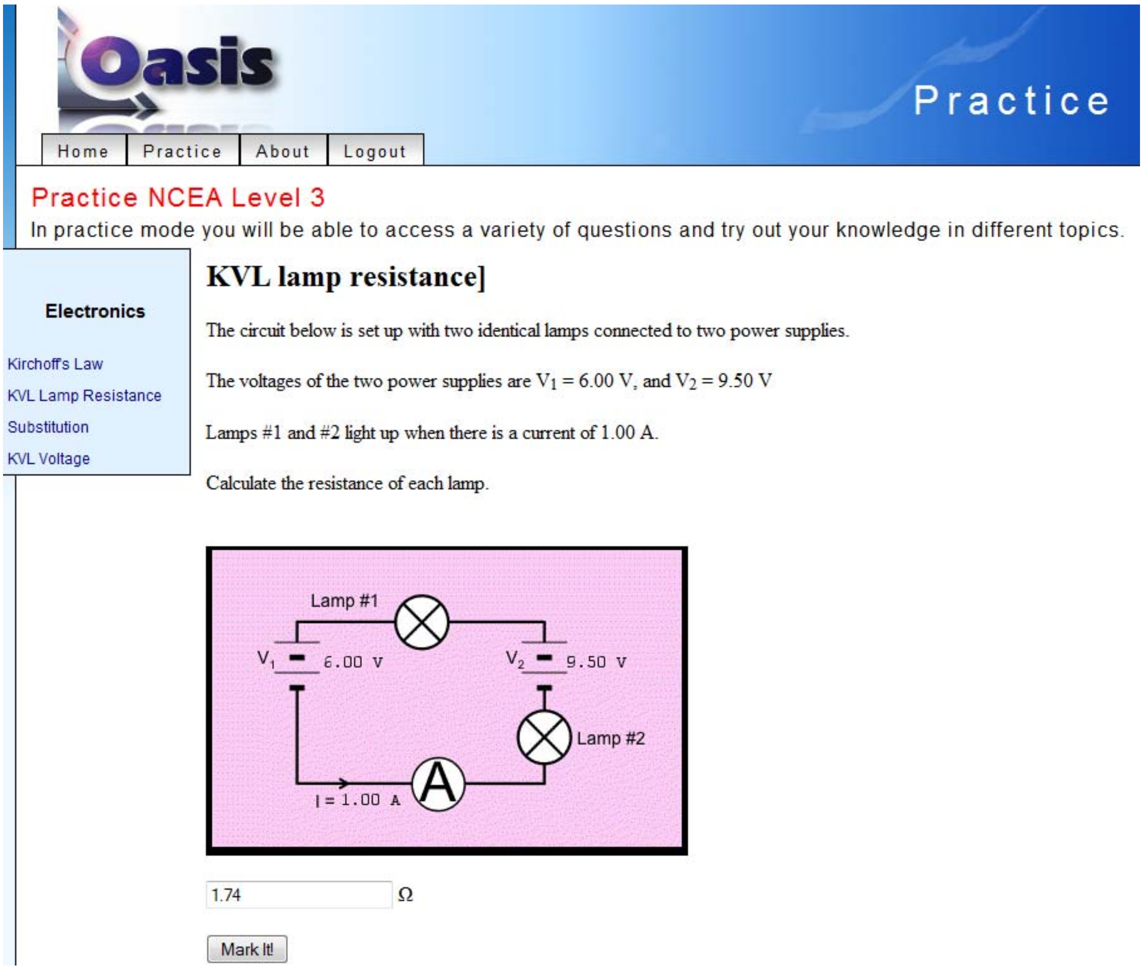

Figure 1: OASIS question for Year-13 Physics.

Most questions are numerical, involving a fixed situation but with variables which change in value from one variation of the question to the next. Figure 1 shows a typical numerical year-13 question. In a minority of questions, slightly different configurations exist within a single question. For example, while students repeating an electric-circuit question are normally confronted with the identical circuit but with changed values for the relevant quantities, some electric-circuit questions contain different circuit configurations so that students repeating these questions are confronted with a non-identical, but similar, circuit. The answers for all variations of each question are already stored in the question database. Consequently, marking generally involves comparison rather than calculation and poses only a minimal load on the computer. Even though some multi-part questions are marked consequentially, involving a somewhat greater load, a few thousand concurrent users could be comfortably handled by any current mid-range home-office desktop computer without loading problems.

School OASIS: software development

The existing OASIS software provided the basis for School OASIS, but some modifications were deemed desirable or necessary. For example, the current version of OASIS is designed to handle up to 5000 concurrent users, but School OASIS potentially has to support far more students, so the system, servers, database, and related components were all re-architected to achieve this support reliably. CouchDB rather than PostgreSQL is used for the School OASIS database. The interface was also redesigned in order to appeal more to high-school students.

A number of further necessary changes centred on student identification and login, and instructor data-access rights. Here there are clear differences between high schools and universities. For example, at UoA a course coordinator can access all data for all students who have attempted any questions for the course. However, the teacher of a particular high-school class should normally have access only to data for students in that class.

Formal assessment

A GUI assessment generator enables instructors to construct OASIS assignments and tests relatively easily without any specialised knowledge. Such formal assessments consist of a small number of questions to be done by students within a certain time-frame.

For tests, all candidates log on at the same time in a supervised environment. The fact that OASIS uses numerically different versions of the same questions makes cheating extremely difficult. Only the first submissions of students are marked; this prevents students submitting their answers, seeing the correct answers, and then using the 'back button' on their browsers to resubmit the correct answers. However, students can enter and revise all their answers as often as they like before actually submitting them. It is important that computerized tests offer the same flexibility as traditional written tests in this regard (Russell, Goldberg, & O'Connor, 2003). OASIS actually records all student answers; even those entered on the screen but not submitted. This function has been appreciated by students whose computers have crashed part-way through a test prior to answer submission. Remaining time is displayed throughout the test; when time expires, the student is automatically logged off. A five-question test is illustrated in Figure 2.

Some courses are too large to be assessed by tests as described above: there are simply insufficient computers. Assignments may be used to assess such courses. Assignments are similar to tests but are unsupervised, can be taken by students wherever they have internet access, and have a less stringent time constraint. Normally, students are required to complete an assignment in a single one-hour period within a twelve-hour period: one hour after a student logs on, the assignment is closed.

Question creation

Although School OASIS provides many questions, teachers may also wish to create their own. A GUI question composer currently exists that enables instructors to construct OASIS questions for their students relatively easily without any specialised knowledge. However, the school situation is different from the university situation. In the university situation each problem set is used by a single group of students, and a single instructor (or perhaps a very small group of instructors) has an interest in maintaining and adding to it. In the school situation each problem set may be used nationally and many teachers potentially have an interest in adding to it. Issues around quality control are therefore important. For example, a question added by one teacher may be perceived as inappropriate, misleading or of poor quality by others. The answer supplied may not even be correct. Consequently some quality control needs to take place before a question is made available for general use. Currently all questions being added to School OASIS are checked by two people, namely the question author / school teacher and the first author of this paper, before release.

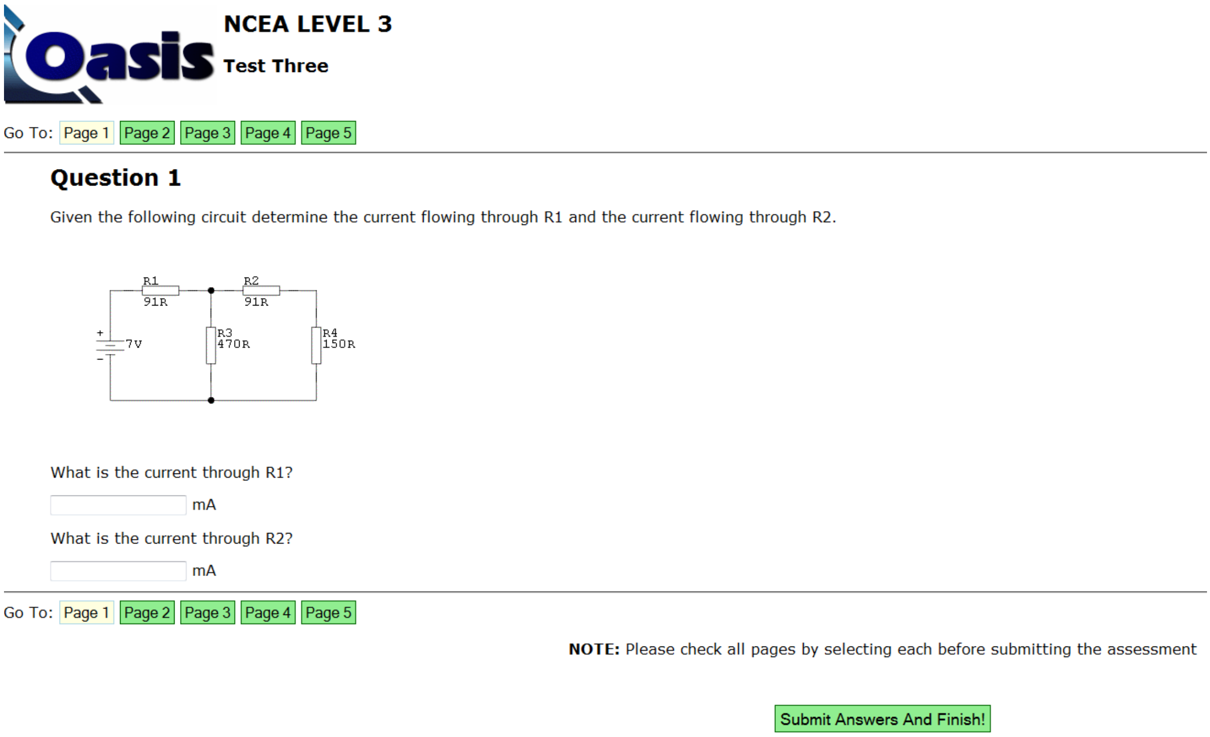

Figure 2: An OASIS test comprising five questions.

Conclusions and future developments

The OASIS software package has been successfully used for university engineering and physics courses for several years. There are 200 to 300 numerical versions of each question, allowing great opportunities for repetition, facilitating student skills practice and development, and making assessment more secure against cheating. Assessments can also be further individualised, with different students receiving different questions. Consequential marking for multi-part questions and repeat attempts for partial credit can also be implemented in assessments to make the process fairer and more student-friendly.

At the end of 2009, ECE began work on School OASIS, a version of OASIS for high-school use. School OASIS provides practice and assessment opportunities for students studying the final three years of high-school physics. It will completely cover the topics necessary for all externally-assessed physics achievement standards of NCEA Levels 1 to 3, the qualifications most-commonly sought by high-school students in New Zealand.

As School OASIS potentially has to support far more students than OASIS, the system, servers, database, and related components were all re-architected to achieve such support reliably. The user interface has also been redesigned to appeal more to younger students.

Through 2010 and 2011, a few hundred questions were written for School OASIS by an experienced high-school teacher. Some teachers and students have already been using the software for skills practice. Consistent with the feedback received from university users, the feedback from these early adopters is encouraging. In the second half of 2011, further feedback from students and teachers will be collected by survey and interview, and by School OASIS itself. Further software enhancements are still to be implemented. In particular, the issues of student identification and instructor data-access need to be addressed, so that teachers can access practice and assessment data for their students but not for others. Once these changes are implemented and School OASIS is operating smoothly, links will be added so students can readily access information about engineering as a career, university engineering courses, and other relevant matters.

With the above changes in place, it is considered that School OASIS will be able to meet its two aims: to improve the physics skills of high-school students, and to increase the numbers of students wishing to study engineering at tertiary level. Additionally, by virtue of the data it collects about student activity, it will become a valuable research tool.

References

Black, P., & Wiliam, D. (1998). Inside the black box: raising standards through classroom assessment. *Phi Delta Kappan, 80*(2), 139-148.

Cantrell, P., Pekcan, G., Itani, A., & Velasquez-Bryant, N. (2006). The Effects of Engineering Modules on Student Learning in Middle School Science Classrooms *Journal of Engineering Education, 95*(4), 301-309.

Cunningham, C. M., Knight, M. T., Carlsen, W. S., & Kelly, G. (2007). Integrating engineering in middle and high school classrooms. *International Journal of Engineering Education, 23*(1), 3-8.

DeGrazia, J. L., Sullivan, J. F., Carlson, L. E., & Carlson, W. C. (2001). A K-12/university partnership: Creating tomorrow's engineers. *Journal of Engineering Education, 90*(4), 557-563.

Freilich, M. B. (1987). A student evaluation of teaching techniques. In M. S. Gupta (Ed.), *Teaching engineering: A beginner's guide*. New York: IEEE Press.

Gattis, C., Nachtmann, H., & Youngblood, A. (2003). The students-recruiting-students undergraduate engineering recruiting programme. *European Journal of Engineering Education, 28*(1), 71 - 82.

Genalo, L. J., Christensen, H. P., & Watkins, S. E. (2007). Guest editorial. *International Journal of Engineering Education, 23*(5), 842.

Gibbs, G. (1999). Using assessment strategically to change the way students learn. In S. Brown & A. Glasner (Eds.), *Assessment matters in higher education: choosing and using diverse approaches* (pp. 41-53). Buckingham, UK & Philadelphia, PA: The Society for Research into Higher Education & Open University Press.

Innis, K. (1996). *Diary survey: how undergraduate full-time students spend their time*. Leeds: Leeds Metropolitan University.

IPENZ. (2007). *Engineering Education in New Zealand – Supply and Demand*. The Institution of Professional Engineers, New Zealand.

Lee, C., Wu, T., Liu, P., & Hsu, S. (2006). Establishing a K-12 nanotechnology program for teacher professional development. *IEEE Transactions on Education, 49*(1), 141-146.

Mehta, S. I., & Schlecht, N. W. (1998). Computerized assessment technique for large classes. *Journal of Engineering Education, 87*(2), 167-172.

Miller, C. M. L., & Parlett, M. (1974). *Up to the mark: A study of the examination game*. Guildford, UK: Society for Research into Higher Education.

Mooney, M. A., & Laubach, T. A. (2002). Adventure engineering: A design centered, inquiry based approach to middle grade science and mathematics education. *Journal of Engineering Education, 91*(3), 309-318.

NAS. (2007). Rising above the gathering storm: energizing and employing America for a brighter economic future   Retrieved from http://books.nap.edu/catalog.php?record_id=11463#toc

Orsak, G. C. (2003). Guest editorial K–12: engineering's new frontier. *IEEE Transactions on Education, 46*(2), 209-210.

Poole, S. J., DeGrazia, J. L., & Sullivan, J. F. (2001). Assessing K-12 pre-engineering outreach programs. *Journal of Engineering Education, 90*(1), 43-51.

Richards, L. G., Hallock, A. K., & Schnittka, C. G. (2007). Getting them early: teaching engineering design in middle schools. *International Journal of Engineering Education, 23*(5), 874 - 883.

Russell, M., Goldberg, A., & O'Connor, K. (2003). Computer-based testing and validity: a look back into the future. *Assessment in Education, 10*(3), 279-293.

Smaill, C. (2005). The implementation and evaluation of OASIS: a Web-based learning and assessment tool for large classes. *IEEE Transactions on Education, 48*(4), 658-663.

Smaill, C. (2007). *Student Voices: the Response to a Web-based Learning and Assessment Tool in Electrical Engineering.* Paper presented at the Proceedings of ASEE Annual Conference and Exposition,, Honolulu, Hawaii, USA.

Smith, N., & Monk, M. (2005). Attracting tomorrow's engineers: an evaluation of a scheme to enhance recruitment into engineering. *European Journal of Engineering Education, 30*(2), 233-243.

Snyder, B. R. (1971). *The hidden curriculum*. New York: Knopf.

Sorby, S. A., & Schumaker-Chadde, J. (2007). Partnering to bring engineering concepts to elementary students. *International Journal of Engineering Education, 23*(1), 65-72.

St Pierre, J., & Christian, J. (2002). *K-12 initiatives: increasing the pool.* Paper presented at the ASEE/IEEE Frontiers in Education Conference, Boston, MA, USA.