"OASIS-F": DEVELOPMENT OF A FUZZY ONLINE ASSESSMENT SYSTEM

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Abstract

A web-based tutorial and examination system has been developed in the Department of Electrical and Electronic Engineering at The University of Auckland. OASIS is an **O**nline **AS**sessment and **I**nformation **S**ystem. OASIS comprises an extensive question database and server-side program that delivers questions to students, marks their responses and records students' activities and performance. In OASIS skills are developed by solving practical problems, which are all marked to give instant feedback. The students can practice on these problems from any web browser at any location on or off campus. Using OASIS does not require any special application software since all of the processing is done on the web server.

Since 2000 the emphasis has been on giving students core-competency and skills but in a further development of OASIS a 'fuzzy' marking scheme is being introduced to allow marking of 'softer' subject material where 'crisp' numerical answers are inappropriate. Thus it will be possible to assess a student's 'understanding' of some topic. OASIS-fuzzy allows a consistent marking scheme for these situations by assessing the student's ability to 'see the wood for the trees'. In OASIS-fuzzy the system measures what is in effect the 'centre of gravity' of the student's knowledge on a particular topic by assessing their ability to rank information about that topic in order of importance. This we believe to be a measure of their 'understanding' of the topic.

This paper presents a brief description of the system, its structure and its features.

Introduction

In recent years the number of students enrolled at The University of Auckland, School of Engineering in general and in the Department of Electrical and Electronic Engineering in particular has increased significantly. With class sizes as large as 250 in Part II and more than 180 in Part III, the marking of coursework amounts to hundreds of hours. If the increases in cost and resource constraints are added to this, then adopting efficient ways to conduct assessment becomes more necessary. Any reduction of marking hours without compromising quality would greatly benefit institutes with large class sizes.

Over the past few years several computer-based tools (CBT) have been developed in order to assist the University instructors in delivering and assessment of courses. Many of them like *WebCT* (WebCT Inc., 2001) or *Blackboard* (Blackboard Inc., 2002) are designed for course development and flexible delivery of course material. Some of these tools as well as most in-house developed computerised assessment systems (CAA, 1999-2001) can only conduct knowledge-based tests. In most cases these tests are in the form of multiple-choice questions.

As any educator would agree the objective of many teaching programs, especially in the field of Engineering, is not only to improve understanding and knowledge of students but also to develop their skills in solving problems. Electrical circuits are the lexicon of Electrical Engineering as the Times Tables are for Mathematics. The authors' experience indicates that students who do not acquire basic skills at earlier stages in their Electrical Engineering study, are not able to attain the knowledge and understanding expected of them in more advanced courses.

Using traditional systems i.e. tutoring-test-further tutoring to improve the skills of students without considerable resource and time, is particularly difficult. Thus any CBT system that can provide skill-based assessment is valuable.

Furthermore education experts seem to agree on the value of formative assessment at the tertiary level (Orsmond et al., 1997; Paxton, 2000). A computer-based self-assessment system can be a strong formative education tool by providing instant feedback to large numbers of students in a way in which most tutors cannot.

Background

During 2000 and 2001, a web-based tutorial and examination system was developed in the Department of Electrical and Electronic Engineering at The University of Auckland. It is called OASIS short for **O**nline **AS**sessment and **I**nformation **S**ystem. OASIS comprises an extensive question database and server-side program that delivers questions to students, marks their response and records students' activities and performance. The interface to the system is through a standard web browser. The browser provides a consistent 'look' and high quality graphics. High quality circuit graphics for electrical

engineering exams have always been very desirable yet difficult to achieve without high definition printers.

OASIS is concerned with building students skill levels and understanding of their subject. Here skills are developed by solving practical problems which are all marked to give instant feedback. The students can practice on these problems from any web browser at any location on or off campus.

Each time students use OASIS they are directed to select a topic of their choice from a menu and from there they can practice a number of questions. Every time a student tries a question OASIS loads the question with different randomly selected component values. The components, which have values, randomly selected by the computer are displayed on the diagram. The student may then answer the question and submit answers. The system will grade and record the results. The correct answers and the students' marks are displayed for them and they can then try the same question with different values or proceed to the next question.

To illustrate the function of OASIS, the example below is taken from a Circuit Analysis course at Part II level.

Circuits and Systems (First Section)

For the circuit shown;

390R

270R   120R

6 V   120R

Load

R_x

(i) For maximum power in the load calculate the value for R_x:

[_____] Ohms

(ii) Calculate the maximum power that could be dissipated in load R_x:

[_____] watts

Submit | Save

Figure 1. Sample Question from OASIS

Every time this question is loaded off the server it shows different values for the voltage source in the circuit as well as for the four given resistors in Figure 1. The students can then use those values to calculate the unknown values asked for in the question. The answers are entered in the two boxes provided in the question.

Students can then click on the Save button shown at the bottom of Figure 1 to save the answers if they want to have more time to revisit the question and modify the answers.   Otherwise clicking on the Submit button marks the question and the students' answers and the correct answers are displayed. (Figure 2)

Question 25

part	Your Answer	Correct Answer	Mark
1	79.8658	79.8658	✓
2	0.3768	0.2469	✗

Try Again

Figure 2. OASIS marking page

If students want to retry the same question they can click on the *Try Again* button to load the same question with a new set of values for the voltage source and the resistors.   Students are encouraged by the lecturer/tutor to attempt all the questions by a variety of methods so that as their skills grow their understanding is also increased.

Using OASIS does not require any special application software since all of the processing is done on the web server. The load on the server is minimised by using a client browser and SQL database on the server. The server that is currently used is a dual Pentium II with the speed of 300MHz and 1GB RAM. This server can easily handle more than 300 users at one time with no loading problems.

As the results for each student are recorded on the server, the instructor can monitor the performance of students for every question.   The tutor can analyse performance and assist where necessary. Our emphasis is on giving students core-competency and skills.   Some students will take longer to achieve the required levels but all students can monitor their own performance.   In an OASIS test, copying is not possible and memory counts for little. It is a true test of specific skills.

There are two modes of operation for OASIS:

OASIS Practice
In practice mode, OASIS allows students to familiarise themselves with the test environment before the actual test.   This minimises the probability of student failure due to unfamiliarity with the online testing environment. Practice mode also helps students to improve their skills through retrying and instant feedback.   In a traditional system it would not be practical to provide as many questions to students and mark them so rapidly.

OASIS Test

OASIS can also operate in test mode in which the instructor can set-up an exam where students attempt the entire exam online and receive their marks as soon as they submit their answers. In the test mode students are given the same questions, however the variables are different for every student. The possibility of cheating is minimised and very little supervision is required.

Before submitting the final answers, students are given a second chance to check their answers in order to avoid submission by mistake. Once they receive their marks OASIS deactivates their login rights and stores the marks in the database. Storing all the data on the database reduces the administrative workload of the course.

The development here is concerned with the problems involved with large classes and achieving consistency and accuracy in assessment. The students gain skills by practicing regularly on OASIS. The same interface is used in a test environment where prior familiarity gives them confidence.

In future development it is envisaged that questions can be broken up into steps and students can proceed only if they finish each step successfully. This 'tutorial mode' would be helpful for large complicated questions.

Measuring understanding- OASIS-Fuzzy

There have been several attempts in using Fuzzy set theory in evaluation and assessment tasks (Klirm et al. 1995; Feng et al. 1999; Ma 2000). It is an effective method to represent the uncertainty and fuzzy terms in the assessment environments. Echauz and Vachtsevanos (Echauz et al., 1995) presented a fuzzy grading method that utilises students' and instructor's performance measure to produce a rather 'fair' mark distribution. In another exercise Rantjt (Ranjit, 1995) used a fuzzy set to evaluate students' answer scripts.

In a further development of OASIS a 'fuzzy' marking scheme is being introduced to allow marking of 'softer' subject material where 'crisp' numerical answers are inappropriate. Thus for example it will be possible to assess a student's 'understanding' of some topic. For example in electrical engineering circuit theory where a single circuit might be capable of analysis by any of 6 or 7 separately distinct methods, a student's assessment of the relative merit of each method **without actually solving the problem** is an indication of their 'understanding' of the subject. In another example a student may be asked to write an assessment of some particular circumstance where the amount of information is large and some of it is relevant while other parts are irrelevant. Such an assessment is usually made by requiring the student to write an essay but such essays suffer from variable spellings and grammar errors and cannot be consistently marked. The marking problem is worsened in large classes by having multiple markers each of whom has their own bias.

OASIS-fuzzy allows a consistent marking scheme for these situations by asking students to 'see the wood for the trees'. The students are given a list

of textual phrases and asked to put them in their perceived order of importance – each student will have their own rank order for each particular circumstance. In a separate exercise the tutors agree on weighting for each text phrase in the particular example. Several phrases may have the same weight but the sum of all the marks represents the total knowledge about that topic and should in essence be constant from one question to the next so that the marking standard from one question to the next is consistent.

OASIS-fuzzy marks the question by taking the student's rank order and the tutors' assessment of value into account at the same time. Several combinations are possible but a simple one is to take the top ten and multiply the tutors' mark for the student's first ranked phrase by 10, the second phrase by 9, and so on thus combining knowledge and relative assessment at the same time. A numerical example is helpful. If the top phrases were assessed by the tutors to be worth 10,9,8…1, and were put in exactly the correct order by the student the combined (sum of the products) mark would be 385. If the same top ten phrases were used, but in the completely opposite order (the worst case scenario for a knowledgeable student) the combined mark would be 200 – or 52% of the maximum possible mark. (Note that this ratio tends to exactly 50% as the lengths of the lists are increased.) In practice marks would lie between these two extremes – A^+ to C^- - except for less well informed students who included irrelevant information high in their 'rank-ordered' list.

An example for selecting seven items from a list is illustrated in Table 1 for some student's answer. The maximum possible mark for this example is 371.

Phrase	Student Ranking	Sample Multiplier (Membership function)	Tutors' Phrase value	Partial mark
A	1	10	4	40
X	2	9	8	72
H	3	8	7	56
W	4	7	6	42
M	5	6	9	54
U	6	5	0	0
T	7	4	1	4
Total mark				268 (72%)

Table 1

The example above shows a linear weighting scheme with a linear apportionment of marks. Clearly this is not a restraint. Several phrases can be given the same mark and the weighting does not have to be linear. However in our experience the differences here are small – what is important and influences the student's mark the most is their ability to select the important information (phrases) and place it high in their rank-ordered list. Lower down items have much less effect. In this way the system measures

what is in effect the 'centre of gravity' of the student's knowledge on a particular topic by assessing their ability to rank what they know about that topic in order of importance. This we believe to be a measure of their 'understanding' of the topic.

A set of questions to measure students' understanding of Circuit Analysis methods has been developed for OASIS-F and is scheduled to be tried in the third week of June, 2002 at The University of Auckland.

Effectiveness of OASIS

Evaluation

During 2000, 2001 and the first semester of 2002, OASIS was used in the Department of Electrical and Electronic Engineering in three Part II and one Part III courses. OASIS contributed between 30 to 50 percent of the students' coursework in each course. It was found that students liked the interactive environment offered by OASIS and they generally appreciate the instant feedback they get on OASIS. It was no surprise to see those students who practiced more received higher marks in the OASIS test.

Figures 3 and 4 show the mark versus the cumulative percentage of students for the first test of a Part II course, Circuits and Systems, in 1999 and 2001 respectively.
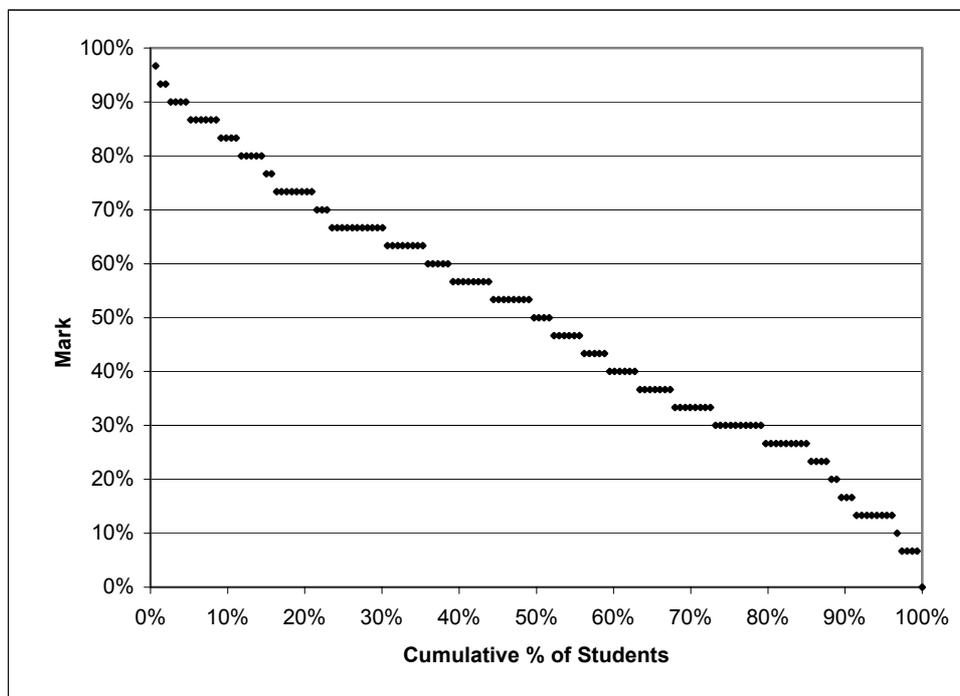
Figure 3, Circuits and Systems Test 1, 1999
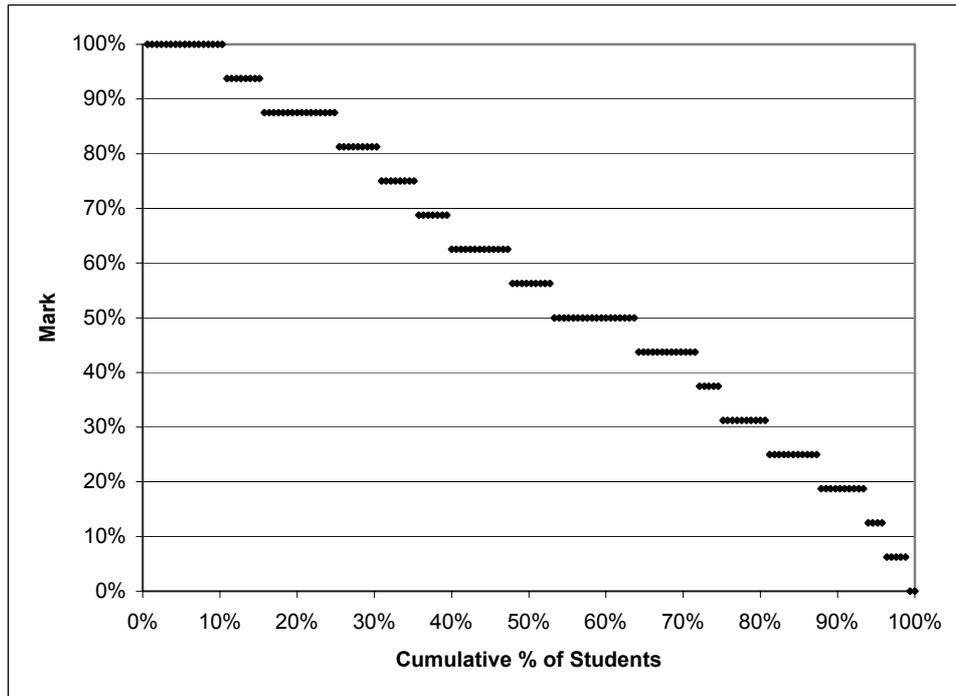
Figure 4, Circuits and Systems Test 1, 2001

The questions on both tests were of similar difficulty, but the students were asked to complete 60% more questions in 2001 so that the overall test was more comprehensive and consequently 'harder'. In 1999 students were given problem sheets with tutorial assistance prior to the test while in 2001 they had access to similar questions on OASIS where they could practice before taking the test.

In both cases the test was designed to assess the basic skills needed in electrical circuit analysis. As can be seen from the graphs, in 2001 more students achieved higher grades and marks in this section of the course compared with those in 1999.

Feedback from Students

In the first semester of 2001, the Department requested the Centre for Professional Development to conduct a formal feedback survey of students enrolled in the Part II Circuits and Systems course. Students were required to do one third of their coursework on OASIS. They were given three weeks to use 'OASIS Practice' to prepare for the test. The survey was conducted after they had finished the test. They were asked to rank OASIS using a five-scale range from Strongly Disagree to Strongly Agree. The full results of the survey are displayed in Appendix A. It was very encouraging to find that 73% of students thought that OASIS had helped them to improve their skills. Only a small proportion of students i.e. 11% said OASIS Practice had not helped them to prepare for the test, and only 18% did not want OASIS introduced in other courses.

Conclusion

With OASIS students can practice as many times as they like and can become confident at answering questions in a low risk, autonomous environment. They are provided with instant feedback and lecture material is reinforced with OASIS.
Students become enthusiastic because they know they can make mistakes without being watched or criticized. The recorded activities indicate that on average, each student attempts every question more than once.

Software Licensing

OASIS software was developed by Senior Tutors in conjunction with lecturing staff and is licensed to the Department of Electrical and Electronic Engineering at The University of Auckland. Interested parties who wish to test OASIS for their own courses can contact the authors to obtain login rights.

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