AAEE 2012 CONFERENCE
Melbourne, Australia
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Providing the right feedback to the right students: applying an innovative e-Assessment system in engineering education

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BACKGROUND
Formative assessment is regarded as a central element to student learning. Through formative assessment, students are expecting to receive feedback that is supportive, timely and specific. However the marking of assignments brings significant workload to lecturers or tutors, especially for classes with larger cohorts. Moreover educators are often required to cope with the increased number of students with fixed resources.

PURPOSE
The purpose of this project was to identify the top, the medium, and the poorly performed students in a cohort by applying an innovative assessment approach, so that a lecturer could spend more time with those students who need more help. As a result, the marking load is reduced while the quality of learning and teaching is improved.

DESIGN/METHOD
A computer assisted assessment program, eTutor, was applied to the formative assessment. The program allowed resubmission of assignment answers so that errors could be corrected by students. Submitted answers were marked automatically so that the marking load was reduced. Students' performances were identified by examining the grades and the number of submission times. The effectiveness of the project on learning was verified through student evaluation.

RESULTS
Results showed that the top students in the class were satisfied by receiving a praise comment given by the program during automatic marking. Those poorly performed students were motivated to actively seek assistance and feedback. The eTutor program was successful in reducing the marking load, in enhancing students' learning interest and in achieving a low failure rate in a subject.

CONCLUSIONS
The eTutor program was efficient in stimulating students' learning interests, minimising plagiarism and reducing educators' marking load. It helped students find their weakness and enhanced their learning experience.

KEYWORDS
e-Assessment; computer-assisted assessment (CAA); feedback

Introduction

Formative assessment is regarded as a central element to student learning in engineering education. The purpose of formative assessment is to collect information which may be fed back to students and to stimulate them to learn about what they might learn better (Brown & Knight, 1994). Through formative assessment, students are expecting to receive feedback that is supportive, timely and specific (Shute, 2008). If students do not get feedback, they are unable to correct mistakes and to improve performance in the summative assessment. While valid and appropriate feedback is highly valued by educators, studies showed that students were not always active in collecting their formative feedback (Jollands, McCallum, & Bondy, 2009; Latham & Faulkner, 2009). It would be a waste of resources if teachers spend many hours giving written feedback and students fail to collect and read the feedback. Late return of marked assignments might be one of the reasons causing this problem since marking of assignments brings significant workload to lecturers or tutors, especially for classes with larger cohorts. In addition, educators are often required to cope with increased number of students with fixed resources due to tight educational budgets faced by many universities around the world. Delayed feedback would have limited effect on teaching and learning, often leading to complaints about the lack of feedback in unit or teaching evaluations. This raises the question of how to give effective feedback.

Some researchers believed that verbal feedback would be effective in giving feedback to a larger number of students (Jollands, et al., 2009). It would be ideal if oral feedback could be given to individual students (Brown & Knight, 1994). However, with the traditional assessment methods, it would be difficult to provide specific feedback in a timely manner to each student in a course with large cohort. To solve this problem, many educators are attempting different computer assisted assessment (CAA) programs to provide fast and direct feedback and to reduce marking loads (Gibson, 2002; Peat & Franklin, 2002; Wang, 2007).

There are a great variety of CAA programs available in the market. A total of 407 CAA software products were listed in the directory of computer assisted assessment products published by Guildford Education Services (GESL, 2000). The purposes of CAA programs are to provide timely feedback to students and teachers, and to reduce marking loads. Teachers have to manage the risks associated with these new assessment methods, such as the cultural shift and the need for designing new assessment tasks rather than using existing assignments (Baillie-de Byl, 2003). Many existing CAA programs are based on multiple-choice questions. The time savings in electronic marking may be offset against the time required to design challenging and effective questions and to provide detailed feedback to students. Many academics find it time consuming or difficult to achieve (Bull, 1999). In addition, there was a concern that multiple choice testing, although more reliable than many alternatives, failed to test ‘real' learning (Falchikov, 2005). The lack of flexibility and complexity in designing a customised engineering problem often discourage the extensive use of existing tools for assessment purpose. They are rarely built in such a way that teachers can adapt them to their specific needs (Ben-Naim & Prusty, 2010).

In this project, a CAA program, called eTutor, was designed and implemented in a number of civil engineering subjects. It aims to identify the top, medium and poorly performed students in a cohort, so that specific feedback could be given to different students. The top students were satisfied by receiving a praise feedback from the program, and those who poorly performed tended to actively seek assistance and feedback so that their performance could be improved in the summative assessment. With the help of the eTutor program, teachers were able to spend more time with those students who need more attention than others in the class, so that the overall performance of the class could be improved. Evaluation results showed that the program had been appreciated by students and recognised by colleagues. The design and implementation of the CAA program are described in the next section.

Method

The design of the eTutor program was started in the beginning of 2010. The system consisted of user and server programs. The primary functions were documented and reviewed before being implemented in engineering courses.

Design of eTutor program

The eTutor program was designed for the assessment of civil engineering assignments. From previous teaching experience, there was an issue of plagiarism in the formative assessment. A study conducted by Palazzo (2010) revealed that time pressure on students who did not start their homework in a timely fashion was the proximate cause of copying. In his study, the fraction of copied problems increased dramatically in long assignments and those of greater difficulty. To minimise plagiarism, unique assignment data were generated randomly within a meaningful engineering range for each student.

To facilitate online marking and to provide instant feedback, real time communication between the user and server programs were established through a network. The system could be designed as a web-based or an application-based system. One of the benefits of application-based program over web-based systems is that students could download an independent package and work on the assignment offline. It only required a connection to the Internet when submitting results. This offers students sufficient time to write detailed calculations and problem solving procedures. Students were encouraged to write detailed calculations step by step, although no hardcopy submission was required. For engineering students, these critical thinking and problem solving skills are important. Another benefit of designing a user program as an independent downloadable package is that each assignment problem could be kept and used for future review purposes. Therefore, in this project each assignment was compiled as an executable file for students to download from the central university learning and teaching web interface. Students were required to use their ID numbers to log in the program.

The assignment questions were designed by taking into account the sound assessment characteristics suggested by Brown (1994). Each assignment problem was designed with a clear purpose, i.e., developing students' ability in structural design through reviewing the knowledge learnt during lectures. Students' performances were judged based on the criteria if correct design principles, equations and parameters were used, and whether the calculations were within the acceptable error percentage. A number of questions were asked for each problem instead of the final answer. When an assignment was finished, instead of submitting the hardcopy, the answers were required to be submitted online for marking. Instant feedback was given to students after automatic marking. A praise comment, such as "All answers are correct. You have finished this assignment. Well done!", would be displayed if no errors were detected, whereas, if there were errors, students were told which submitted answers were incorrect, and they were encouraged to continue working on the assignment before the deadline so that a better mark could be achieved. The final mark for each assignment was the average of the marks obtained in the first and the last submissions. With instant feedback about errors, students were able to keep a note of the reasons leading to the errors, and manage to avoid the same in the future.

The online submission and automatic marking process also provided feedback to teachers. If one or two students do badly in an assignment, it could be assumed that it was the students who needed attention (Brown & Knight, 1994). But when a whole cohort had difficulties in getting the correct answers, this indicated that there might be problems in the teaching or in the assignment.

It appeared that there was a limitation in the types of feedback that could be provided by a computer program (Lowry, 2005). This was the case for most CAA programs as reported by Espasa (2010) that the regulation of learning in online environments is more oriented towards error correction. The feedback from CAA programs basically provides information

about errors made and provides the correct answer, rather than about how to improve work, although students might be provided with hints and other online resources, such as a reference article, a section in the course textbook, web-sites or feedback for common errors (Lee, Palazzo, Warnakulasooriya, & Pritchard, 2008; Miller, 2009). These types of feedback usually do not directly pinpoint the reason leading to the errors, such as wrong equations, wrong parameters or wrong calculations. Students might not be clear where the problem was. In this case, students often come to see a tutor or lecturer for feedback. Through online submission and automatic marking, students were motivated to correct these errors and to get reward marks. They tended to get feedback from peer students through discussion, or to obtain specific hints and verbal feedback from lectures or tutors. Therefore, eTutor program motivated those students who did not perform well to actively seek feedback from teachers. When these students were given fairly detailed comments about the errors they made, they would make an effort to avoid the same mistakes in the final exam. This was supported by the observation that students performed well on those exam questions designed based on the unit content that was assessed in the formative assessment tasks. With the help of the eTutor program, academics could spend more time with those students who specifically required help, so that the overall performance of the enrolment in a subject could be improved.

Although the literature suggests that formative assessment should provide qualitative feedback (Huhta, 2010; Rust, Price, & O'Donovan, 2003), it was found that students would not do activities unless they were worth marks (Parsons, 2007). If weighted assessments were to be part of the learning process, then more emphasis should be placed on earlier, formative assessments that encourage good learning. Therefore, a score was given for each submission.

Implementation of eTutor Program

The eTutor program was firstly tested in Engineering Statics, which was a first year unit with 115 enrolments in 2011. A total of 10 weekly assignments were generated. If submissions were made after a deadline, a message would be displayed telling the student that "the submission of this assignment has been closed. Please submit before the due date next time."

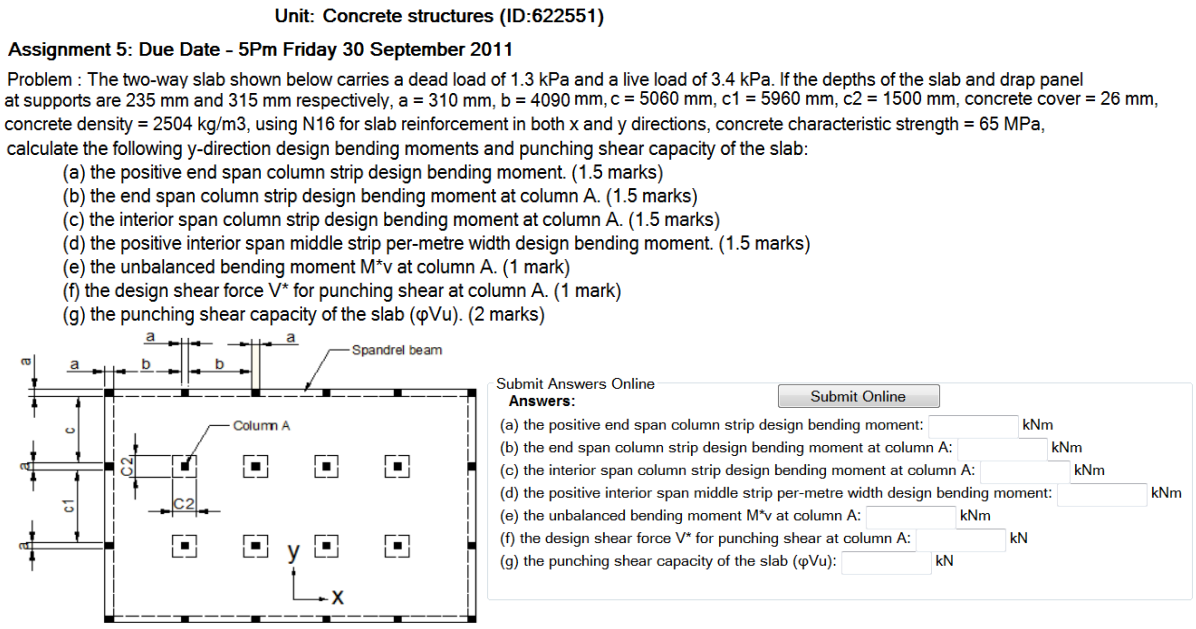

Figure 1: The user interface of an assignment problem

The eTutor program was also implemented in two other units, Steel and Timber Structures, and Concrete Structures. The design equations and relevant parameters were incorporated into the program. Figure 1 shows the user interface of the program.

It can be seen from Figure 1 that the assignment contains the problem description with a supporting diagram. Students were recommended to print a hardcopy of the problem and finish the assignment step by step on assignment answer sheets. The difference between the electronically distributed assignment and the traditional assignment is that the answers were unique for each student due to the unique problem data being generated for each student. It would be impossible for a student to directly copy other students' work. Therefore the eTutor program efficiently reduced plagiarism as evidenced in students' feedback:

Weekly assignments force to learn/study. Assignments were unique, therefore no copycats.

When a submission deadline was reached, each student received a mark for that assignment. The marks were also recorded by the program. No additional marking was required. During the submission process, students were active in seeking assistance from peers or from the lecturer if they encountered difficulties in getting the correct answers. During a consultation, not only the reasons leading to the errors were pointed out, the students' weak points in the study of the unit were also advised by the teacher. Therefore, the eTutor program freed teachers from heavy marking loads and allowed them to give specific feedback to those students who needed specific help.

The effectiveness of the eTutor program was evaluated and reported in the next section.

Evaluation of eTutor Program

The evaluation of the eTutor program was conducted through questionnaires that were distributed to students during the last week of each unit. Comments and feedback from colleagues about the program were also received when the results were presented in a research seminar.

Student Evaluation of eTutor Program

The evaluation of the eTutor program was conducted through questionnaires that were distributed to students during the last week of each unit. A total of 145 students participated in the paper based survey, representing 86% of the total enrolment. The survey questions aimed to test the effectiveness of the eTutor program. Detailed questions included:

Question 1: I prefer online submission of Assignments;

Question 2: Online submission increases my interests in each assignment since I can get instant feedback about any wrong calculations;

Question 3: Correcting errors in each assignment helps me understand the unit content;

Question 4: I will start working on assignments earlier rather than waiting until the due date.

Students were given the choices of selecting “strongly agree, agree, neutral, disagree or strongly disagree” for the four survey questions. To obtain qualitative data, a number of open-ended question were also asked in the survey: "Please give your comments, ideas or suggestions on improving the program. Do you think the feedback is sufficient and helpful? What other feedback you expect to receive instantly?"

Students' responses to the survey questions are shown in Figures 2. The survey results indicate that the majority (70%) of students preferred using eTutor for the submission of assignments. Similar proportion of students agreed or strongly agreed that their learning interests were motivated due to the instant feedback given by eTutor. It appeared that the

eTutor program helped students understand the unit content. More than 70% students agreed or strongly agreed that they learnt better through correcting errors in assignments.

It is interesting to note that the eTutor program did not change students' behaviour in terms of when to start working on an assignment. This may be due to the fact that each student usually enrolled in an average of four units each semester and they had to keep their study pattern in order to cope with the deadlines of assignments in each unit. This was based on the observation of students' behaviour.

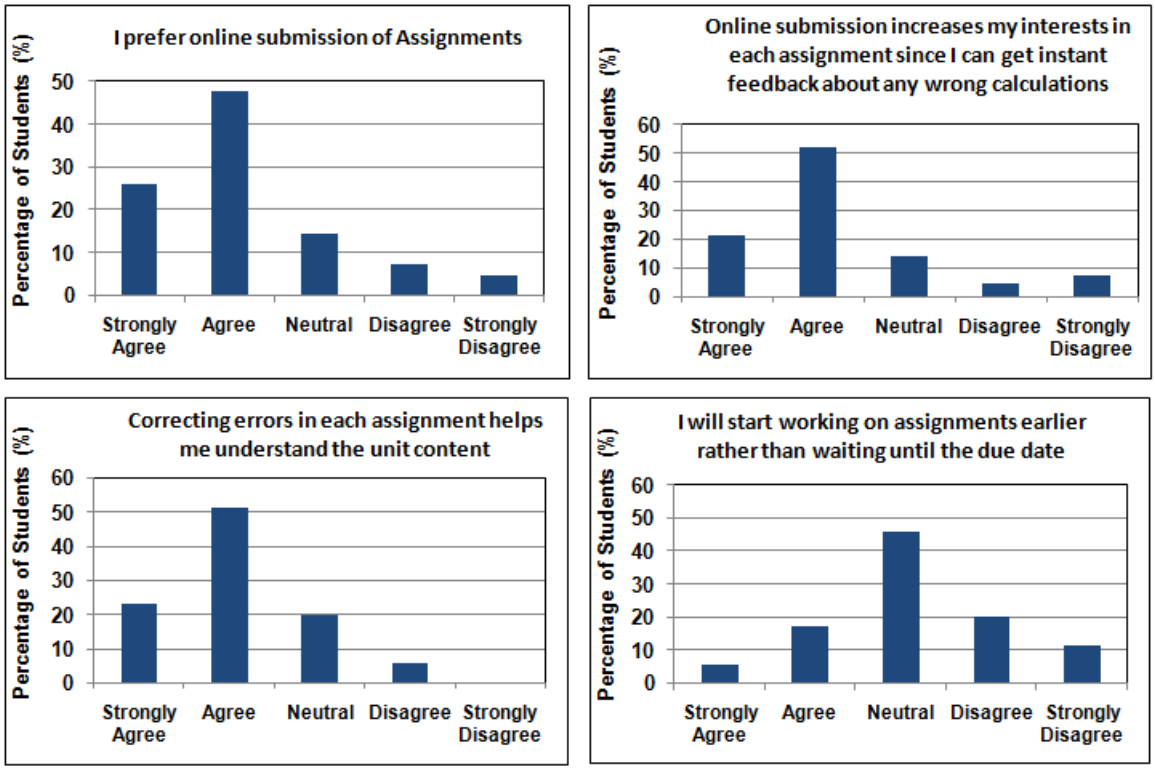

Figure 2: Students' response to survey questions

Students also gave general comments about eTutor program in the responses to the open-ended questions. Comments, such as "The program forces me to learn by myself.", indicating that the program worked well in encouraging learning and reducing plagiarism.

Many students appreciated the convenience in submitting assignments with comments like:

> *It makes submission easier, quicker and more effective, also gives me a chance to fix mistakes if I bomb out on the first submission.*

The features of instant feedback and online marking were also extensively acknowledged. One student expressed that:

> *The instant feedback was helpful. The program give me a chance to correct errors and re-submit. Another good thing is that students didn't have to wait until the following week to get the results.*

Survey results revealed that students were motivated to learn from the errors they made during the assignment submission process. "Without the program, it would be too late to correct the mistakes I made." Another student commented that:

> *I think the move towards this instant feedback system is very beneficial in allowing students to find their weaknesses and tackle them before being bogged down with more assignments.*

With these benefits of the eTutor program, some students expected that the program could be applied to other units in the future. Comments included:

> *Online submission of assignments was an excellent idea. Instant feedback was so helpful. The quality of learning was getting high. Instant online marking was a relief for most of us.*

While the results were promising, the program could be improved in many ways. When being asked if the instant feedback was sufficient, many students expressed their willingness to get more specific feedback other than which answers were incorrect. Detailed comments include:

> *I know it is a bit hard to do this but I wish there would be more comments in the feedback that makes things clear. Unlike the hardcopy, the online submission doesn't show where you made a mistake.*

Some students preferred to get verbal feedback during face-to-face consultations:

> *Both hardcopy or online submission version of assignments are fine as long as the lecturer is available for questions before the assignment deadline.*

Students also gave suggestions on future improvement in the following aspects:

- "Release answers online straight after deadline."
- "Give partial marks for wrong calculations when correct methods were used"
- "Add a function to allow submitting diagrams in addition to numerical answers"

These suggestions will be considered when conducting future development of the eTutor program.

Feedback from colleagues

Positive comments and feedback were also received from colleagues when the results were presented in a seminar:

> *The program had addressed an issue of how to improve the quality of teaching and learning with fixed resources and increased enrolments in universities. The project had responded to a need that applied not only to engineering disciplines but to many academics working in Higher Education.*

It was suggested that comprehensive assessment approaches, including assignments, laboratory tasks and mid-semester tests, be adopted in order to increase the overall quality of teaching.

Discussion

Students' submitted answers were recorded together with the submission date and time. These data were analysed and shown in Figure 3.

It can be seen from Figure 3(a) that around a quarter of students got all answers correct in the first submission. About 70% of the remaining students managed to correct all the errors after a number of submissions (Figure 3(b)). More than 80% of students submitted two or three times for each assignment as can be seen from Figure 3(c). It took less than two hours for most students (around 70%) to finish the assignment as shown in Figure 3(d). It should be noted that the time period between the first and the last submissions might include time spent on other activities; and the total time to finish an assignment depended on how difficult the assignment problem was.

These results revealed that around 30% students might have encountered difficulties in the assignments. The eTutor program helped to identify these students and encouraged them to actively seek feedback from the teacher so that he or she could improve learning in the units. Large amount of students' emails had been answered and face-to-face consultations had been provided regarding questions on each assignment. In general, the eTutor program made it possible for teachers to provide specific feedback and advice to these students who need more assistance in a unit.

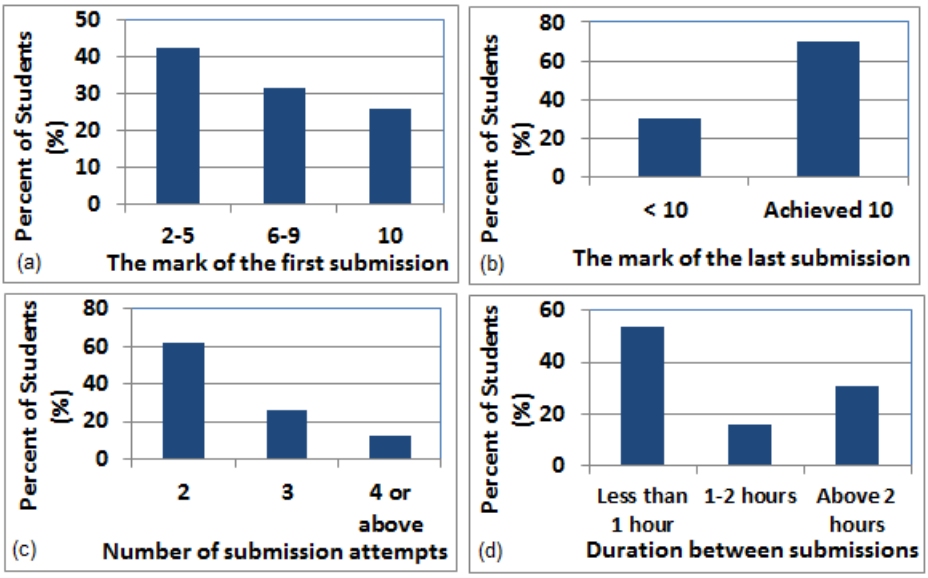

Figure 3: Students' submission results

Limitations

The eTutor program is only applicable to number based assessment tasks rather than lab reports or essays. The program has only been tested in a limited number of units. More tests are expected in the future on other engineering discipline units.

Conclusions

This paper presented an innovative computer assisted assessment program, that was implemented and tested in a number of engineering units, such as Engineering Statics, Concrete Structures and Steel and Timber structures, for online submission and automatic marking of formative assessment. Results showed that the program was efficient in stimulating students' learning interests, minimising plagiarism and reducing marking load, whilst retaining the ability to give students feedback. It was supported by the evidence that students spent more time by correcting errors they made and re-submit in order to achieve a high mark. Students were given multiple chances to correct errors before assignment deadlines. It helped students find their weakness and enhanced their learning experience. It also freed academics from marking hardcopy submissions and allowed them to spend more time with poorly performed students in the class by giving specific feedback through face-to-face consultations. More functions will be added in the future development of the program.

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Acknowledgements

The authors would like to acknowledge the support of the project by UTAS through a teaching development grant.

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