

Developing computer assisted assessment program for civil engineering courses

Hui Jiao

University of Tasmania, Hobart, Australia
hjiao@utas.edu.au

***Abstract:** This paper describes the development of a computer assisted assessment (CAA) program, called e-tutor. The functions of e-tutor include online submission and automatic marking of assignments. The marking time is significantly reduced when checking hardcopy submissions and providing feedback to students. There are two components in the system. The students' end program provides the designed problems with randomly generated numbers for each student. Students are required to finish each problem step by step and submit interim and final answers online. The teacher's end program processes the students' electronic submissions through automatic marking. The CAA system proved successful in significantly reducing a teacher's marking load, providing feedback to students, efficiently eliminating plagiarism and encouraging students' learning enthusiasm.*

Introduction

As a central element in teaching and learning, assessment plays an important role in measuring expected intended learning outcomes and providing opportunities for students to self-monitor their learning progress. A well designed formative assessment task will provide feedback to both students and teachers on how learning is proceeding (Biggs & Tang, 2007). Generally, assignment or tutorial problems are developed for strengthening theories introduced during lectures or enhancing students' problem solving skills.

The traditional hardcopy submission of assignments works well in achieving this goal in university teaching and learning practice. However, marking of assignments brings significant workload to lecturers or tutors, especially with larger cohorts. The teaching quality might be affected without timely return of marked assignments and feedback to students due to the workload. Methods frequently employed to reduced the workload, as enumerated by Race, Brown, & Smith (2005), include implementing multiple choice sheets marked using automatic systems; replacing assignments with examinations; using online quizzes and introducing peer assessment. The use of computer assisted assessment (CAA) is regarded as an effective solution.

There are a large number of CAA systems that provide assessment functions. However, the types of questions supported by these systems are often limited to multiple choice, true-false, or fill-in-the-blank, etc. The lack of flexibility and complexity in designing a customized engineering problem often discourage the extensive use of those tools for assessment purpose. For example, Blackboard Vista Version 4 that is used at UTas, mainly supports true/false, fill in the blank, matching pairs, multiple choice and short answers. Although the assessment can be conducted online with automatic marking, there is a concern that multiple choice questions fail to test 'real' learning and may promote surface approach to studying (Falchikov, 2005). Davis (2009) implemented quantitative courses using two online assessment systems WebCT and Maple TA. Although partial marks can be awarded when students get part of the question right, there is a limitation in designing the question in desired manner.

Another disadvantage of those CAA systems is the lack of formative feedbacks to students and teachers. With the automatic marking, a mark is given to each student without explanation how and why a mistake was made. The teacher does not have a clue if an error was made due to wrong

calculations or by taking wrong parameters. Marking is qualifying learning performance (Biggs & Tang, 2007). Since teachers are not involved directly in the marking process, they could not give feedback to individual student. This is a significant drawback of those CAA systems comparing to hardcopy submissions. Therefore detailed and in time feedback will not only give students opportunities to review their errors so that better performance could be achieved, but also help teachers to pinpoint the lecture contents that may need to be reiterated during lectures.

To address these issues, a CAA system, called e-tutor, was developed at UTas to assist marking assignments of civil engineering units, such as mechanics of materials, steel and timber structures, and concrete structures. The system consists of two components, the student's end and the teacher's end programs. In addition to hardcopy submissions, students are required to submit the final answer and interim calculations in each step online.

E-tutor works well in reducing teacher's marking load, eliminating plagiarism, and stimulating student's enthusiasm and involvement in learning.

Development of e-tutor

There are options to develop the program as web-based or application-based. A web-based program will load up an assignment problem in a web browser that transfers solutions to a web server for automatic marking. As an initial trail of the system, application-based programs were developed for both student's end and teacher's end programs.

Students' end program

The student's end program was developed in VB.NET. Assignment problems were shown in textboxes with diagrams displayed in pictureboxes. It gives different numbers to different students. The numbers for each problem are generated randomly within a meaningful engineering range preset when designing the program, and linked with each student's ID number.

An executable file is generated for each assignment and uploaded to MyLO (A web server using Blackboard Version 4). The executable file will run and display the designed assignment window directly on any computers with Microsoft.Net installed. No other installation is required. Since Microsoft.Net is freely available from the web and is pre-installed on new computers, running the program is not an issue except for Mac PCs.

A student ID number is required to log in the assignment. The numbers to the problems associated with the student ID number are stored in a multiple array. If a student is not enrolled in the course when the program is released, a default set of numbers will be used.

By entering an ID number and click 'Enter', the window will be updated with the assignment problems as shown in Figure 1. Students can print a hardcopy or generate a pdf file of the assignment sheet if they wish by clicking the 'print' button. Clicking the 'Submission Requirement' button on top of the program will pop up a dialog box describing how to submit the answers electronically as well as a hardcopy manually with detailed calculations.

With the assignment problems in hand, students can work out the solutions step by step and write their answers on papers. Before submitting the hardcopy assignment by the due date, students are required to enter the answers to each problem into the textboxes located at the right bottom corner of the assignment window. The answers will be saved as a text file that contains the ID number and assignment number as part of the file name. Then, the text file is submitted to MyLO assignment submission box electronically.

It needs to be pointed out that the online submission of assignment calculations via the e-tutor program will not replace the hardcopy submissions. It is believed that hardcopy submissions of assignments will help students to develop important professional skills in engineering design by performing detailed calculations and presenting their analysis and design clearly in writing. The intension of the e-tutor program is to bring innovations to the traditional marking method and bring distinctive learning experience to students.

UNIVERSITY OF TASMANIA
School of Engineering

Unit: KNE216 Civil Engineering 1 (ID:654321)

Assignment 4: Due Date - 5Pm Wednesday 24 March 2010

Problem 1: For the cross section shown in Figures 1, if $a = 470$ mm, $b = 564$ mm, $c = 188$ mm and $d = 338$ mm, $(x1, y1)$ is the centroid position with respect to point A, calculate:
 (a) $x1$
 (b) $y1$
 (c) The second moment of area about the centroidal horizontal axis

Problem 2: The beam shown in Figure 2 has a symmetrical T-shaped cross-section and is subjected to a uniformly distributed load of $q = 29$ kN/m. If $a = 223$ mm, $b = 55$ mm and $c = 267$ mm, determine:
 (a) The maximum bending moment in magnitude on the beam
 (b) The distance of the maximum bending moment from

Save your answers for online submission

Answers to Problem 1:
 (a) $x1$: mm
 (b) $y1$: mm
 (c) The second moment of area about the centroidal horizontal axis: mm⁴
 (d) The maximum principal second moment of area of the section: mm⁴

Answers to Problem 2:
 (a) The maximum bending moment in magnitude on the beam: kNm
 (b) The distance of the maximum bending moment from point A: m
 (c) The maximum tensile stress on the beam: MPa
 (d) The maximum compressive stress on the beam: MPa

Figure 1: Assignment window of the student end program

Teacher's end program

The teacher's end program was developed using VBA in Excel. An excel file that contains a number of spreadsheets, including marking sheet and assignment sheets, is associated with an automatic marking VBA function. The marking sheet contains the summary of student marks for each assignment, while the problem inputs and answers for each assignment are stored in each assignment sheet.

When the automatic marking function is executed, it opens up the student submitted text files that were downloaded from MyLO, and compares the submitted numbers with the corresponding answers. An error percentage was adopted when making the comparison by taking into account the rounding errors of students' calculations. All submitted numbers were copied to the relevant spreadsheet with any wrong calculation marked with red colour in the cell as shown in Figure 2. Final marks were recorded in the marking sheet. Partial marks are awarded if a number was wrong due to wrong calculated results in previous steps.

	Answers									Students' calculations						
	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB
1	HA (kN)	RA (kN)	NAB (kN)	VC (kN)	MB (kN)	NAE (kN)	VB (kN)	MC (kN)			NAB (kN)	VC (kN)	MB (kNm)	NAE (kN)	VB (kN)	MC (kNm)
2	40.59	57.94	25.65	-63.15	141	-67.24	-22.00	-81.18			25.65	63.15	148.5(141.0)	62.8(-67.24)	27.8(-22.00)	49.5(-81.18)
3	68.47	92.85	-14.1	-60.9	118.5	-110.49	-33.20	-136.94								
4	56.12	85.59	5.4	-45.4	95.5	-96.25	-34.80	-112.24			-5.4	45.4	-95.5	-96.25	56.12(-34.80)	-112.2
5	49.41	81.56	-7.35	-50.15	99.5	-88.46	-35.60	-98.82			-7.35	-50.15	111(99.50)	-44.7(-56.46)	11.6(-35.60)	-118.5(-98.82)

Figure 2: Illustration of teacher's end program

Checking hardcopies and providing feedback

Based on the marks obtained from e-tutor, it would be easy when checking the hardcopy submissions and giving feedback to each student. Since wrong calculations had been detected by e-tutor, it only

needs to pinpoint the reasons behind the mistake. For instance, a mistake could be due to using wrong equations, taking wrong parameters or carelessness in calculations. Detailed feedback based on the performance of each individual student was written on the hardcopy submissions and returned to students in time. In this way, students would have a knowledge why a mistake was made and how to avoid similar mistakes in the future.

By checking the errors picked up by the e-tutor program, the teacher could also learn the common errors made by students, so that the theories and principles related to those problems could be reiterated during lectures.

With the help of e-tutor, the time spent on checking the hardcopies and giving feedback could be significantly reduced, since only those errors picked up by e-tutors were needed to be checked. Therefore, the hardcopies with a teacher's feedback could be returned to students in a timely manner.

Figure 3 shows a comparison of marking time a teacher could spend in marking the assignments of 100 students with and without e-tutor. Assuming 3 minutes are required in marking one assignment that contains 10 questions with one mark for each question. The average time spent on each question is 18 seconds. Without e-tutor program, the total marking time would be 5 hours. With e-tutor, the time spent is inversely proportional to the e-tutor marks. For example, if a student got a mark of 9 from e-tutor, it only needs 18 seconds to check the hardcopy why it was wrong. It can be seen from Figure 3 that two thirds of the marking time could be saved with the help of e-tutor program.

It needs to be pointed out that marking time may vary for different courses. The efficiency of e-tutor program in reducing the marking load needs to be further verified by other lectures in the future.

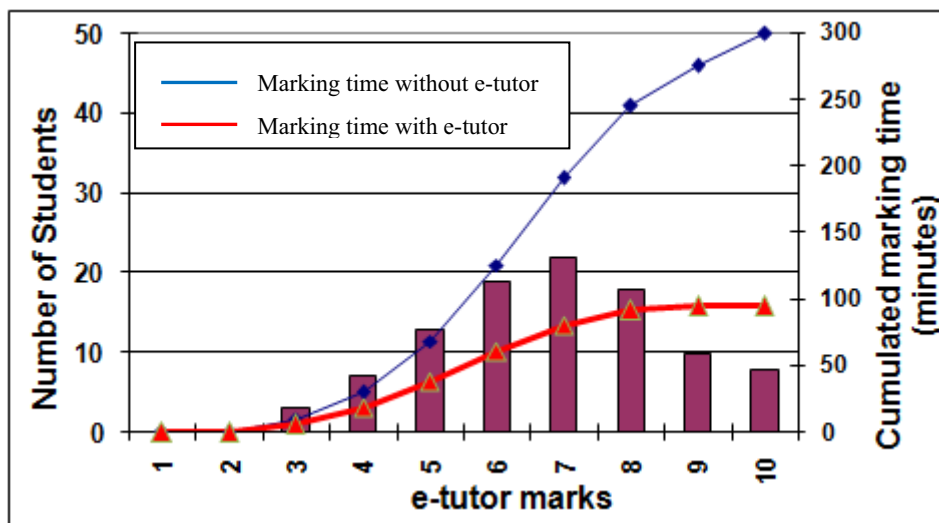


Figure 3: Comparison of marking time with and without e-tutor

Correlations exist between the e-tutor marks and the quality of hardcopy submissions. Usually, those students who got full marks from e-tutor had done a tidy and nice job on their hardcopies, while those who were marked poorly by e-tutor might have finish the assignment in a rush.

There is a potential to let e-tutor providing similar feedback and reporting common errors to a teacher by writing more functions. However, the hardcopy submissions are still necessary when students are required to draw diagrams in solving assignment problems, such as finding the most critical beam section by plotting bending moment diagrams, or using Mohr's circle to find the principal stresses, etc.

Courses implemented with e-tutor

Mechanics of materials

It was found e-tutor can be easily used in designing assignment problems in the course of mechanics of materials. Generally, the loads applied on a beam or frame, and the position of the loads could be generated randomly within a meaningful engineering range and allocated to different students. The internal forces at different positions on the structure may be calculated and submitted via e-tutor. The cross-section dimensions of a beam in bending or a shaft in torsion may also be set up as different numbers for different students, so that different results in beam section properties, beam deflections, bending stresses, or angle of twists of shafts could be determined and automatically marked by e-tutor.

E-tutor was recently implemented in marking the weekly assignments of a 2nd year cohort that consists of 100 students. It proved that e-tutor was efficient in reducing the marking load while maintaining the teaching quality. All assignments were returned to students in time with feedback to each student.

Steel structures

The key issue involved in designing steel structures assignments was how to incorporate the relevant parameters and limits from Australian design code into the e-tutor program. For example, different section dimensions may result in ineffective sections for columns in compression, or in different compactness category for beams in bending. Different equations for calculating the effective section modulus and slenderness limit parameters must be used. All these have been taken into account in e-tutor. Some parameters were calculated using the formulae provided in current steel design code, AS4100, while students might get those parameters from a table, such as the member slenderness reduction factor (α_c). An error percentage was considered when checking students' calculations.

Again, partial marks were awarded if errors were made due to wrong calculations from previous steps. For instance, wrong design bending moment or wrong design loads would lead to errors in the subsequent results. In this case, the wrong design load submitted by a student would be used by the e-tutor program to check the results in the subsequent calculations, if no further errors were detected, only marks from the first step would be deducted.

Concrete structures

No difficulties were encountered when implementing e-tutor to the existing assignments in concrete structures. The input variables that were generated randomly for each student include applied loads, beam section dimensions, the amount and diameter of reinforcing bars. Students were required to determine the stresses in concrete and steel reinforcing bar using both cracked and uncracked elastic beam analysis methods, to check beam and slab deflections under service load conditions, to calculate beam bending moment and to conduct shear design under ultimate load conditions.

It needs to be pointed out that the assignment tasks from e-tutor are still limited to design elements with pre-determined cross-sectional dimensions. Further development is required to include functions for students to design a suitable section based on a given design load.

Students' view on e-tutor

Online submission of assignments was regarded as one of the best aspects in teaching. Positive feedbacks were received from students. Detailed comments included, "The online assignments force me to learn by myself"; "Assignments were marked and returned promptly"; "The assignment marking and random question system worked well and should be used by other lecturers". Many students expressed that it was impossible to simply copy other students' work because the numbers were unique for each student, although the methodology might be the same. To get high marks, it was necessary to fully understand the theories behind the problem and perform calculations carefully. Many students appreciated the assignments being returned in a timely manner, and from those errors in their assignment they had learned how to avoid similar errors in order to achieve better performance in final exams.

Future development of e-tutor

The online submission and automatic marking functions of the e-tutor program are still limited to checking the quantitative components of each assignment. More work is required in providing detailed feedback to both teachers and students. There is a long way to go towards developing more advanced functions, such as checking submitted diagrams and drafting details so that hardcopy submissions could be replaced completely by online submissions.

Conclusion

The e-tutor program can be easily used in designing and marking assignment problems in civil engineering courses. It was efficient in maximizing academic integrity and eliminating plagiarism. The marking time could be significantly reduced in checking the hardcopy submissions and providing feedback to students. It also helped in stimulating students' learning enthusiasm and in increasing their involvement in the learning process.

References

- Biggs, J., & Tang, C. (2007). *Teaching for quality learning at university: what the student does* (3rd ed.). Maidenhead: McGraw-Hill/Society for Research into Higher Education & Open University Press.
- Cohen, L., Manion, L., & Morrison, K. (2004). *A guide to teaching practice* (5th ed.). London ; New York: Routledge.
- Davis, S. (2009). *Creating appropriate online assessment for quantitative engineering courses*. Paper presented at the Proceedings of AAEE2009.
- Dickens, J., & Carol, A. (2009). Key aspects of teaching and learning in engineering. In H. Fry, S. Ketteridge & S. Marshall (Eds.), *A Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice* (pp. 264).
- Falchikov, N. (2005). *Improving assessment through student involvement*. London: RoutledgeFalmer.
- Frankland, S. (2007). *Enhancing teaching and learning through assessment*. Dordrecht: Springer.
- Harris, K.-L. (2005). Guide for reviewing assessment. *Centre for the Study of Higher Education, The University of Melbourne*.
- James, R., McInnis, C., & Devlin, M. (2009). Core principles of effective assessment. <http://www.cshe.unimelb.edu.au/assessinglearning/05/index.html>
- Morgan, C. (2004). *The student assessment handbook*. London: RoutledgeFalmer.
- Race, P., Brown, S. A., & Smith, B. D. (2005). *500 tips on assessment*. London ; New York: RoutledgeFalmer.

Copyright © 2010 Hui Jiao: The authors assign to AaeE and educational non-profit institutions a non-exclusive licence to use this document for personal use and in courses of instruction provided that the article is used in full and this copyright statement is reproduced. The authors also grant a non-exclusive licence to AaeE to publish this document in full on the World Wide Web (prime sites and mirrors) on CD-ROM and in printed form within the AaeE 2010 conference proceedings. Any other usage is prohibited without the express permission of the authors.