Innovative Assessment and Feedback System for Structural Engineering Education

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Abstract: *Commercial Online course management platforms are increasingly used in teaching and learning in many disciplines. However their use for setting assessment tasks in engineering education is often difficult and limited in achieving desired teaching and learning objectives. This is partly due to the nature of engineering exercise problems which often requires equation manipulation and multi-stage problem solving. This paper presents an innovative spreadsheet based tool which is designed to cater for this type of problem. The tool was developed for both formative and summative assessments and with a resource optimal capability to automate both marking and collecting timely feedback from students on their perceived learning. It aims to encourage active learning with activatable hints and to minimise plagiarism by generating individual assignment data for each student.*

Introduction

The innovative use of computers and online course management platforms in teaching and learning has provided a new dimension and increased opportunity in delivering diverse assessments in many disciplines. However, they pose a challenge when it comes to their application in engineering education in terms of adequacy in assessing student work and driving learning. This is because engineering type problems often require equation manipulation and multi-stage problem solving (Bourne et al, 2005, p.15). The setting of assessments for this kind of problem is not catered for in the assessment tools of general purpose course management platforms such as Black Board®. For example the "*Calculated Numeric Response*" question type is not suitable for problems that require evaluating more than one formula per question. While other types such as "*Short Answer*" and "*Essay*" would enable assessing of open ended and multiple formula questions, they require manual grading and thereby reduce the automatic marking advantage of online assessment to just a method of collecting student work electronically.

Motivated by the desire to enhance the quality of teaching and learning while faced by a substantial increase in engineering students and relatively limited resources, the authors have been developing and pilot-testing an innovative tool that utilises conventional spreadsheet software to complement existing online assessment tools and to provide high level assessment for engineering problem solving. The spreadsheet was chosen over other platforms because it is readily available and familiar to most potential users and also offers great flexibility for preparing a wide variety of assessment options. This tool, referred to as *e*-Task, contains several unique features (Saleh, Li, & Nejadi, 2009) and is the subject of this paper. A typical *e*-Task example is depicted in Figure 1.

Methodology

It has been well documented in engineering education literature (Goldfinch, Carew & McCarthy 2008), that many engineering students experience substantial difficulties in learning fundamental subjects such as Mechanics and Structural Analysis. This leads in turn to poor learning outcomes and relatively high failure rates. A list of causes for such problems includes:

- Gaps in assumed prerequisite knowledge (forgotten or did not master earlier).
- Plagiarism in assignment tasks which hinders learning in subsequent topics.
- Lack of timely diagnostic information on students' learning.
- Lack of timely and constructive feedback to students on their learning.
- Large class sizes and diversity in students' knowledge, abilities and attitudes

The *e*-Task system being developed aims to address such problems by systematically integrating assessment and feedback capabilities which are formative, diagnostic, developmental and summative and thereby enhance student learning outcomes in the targeted subjects by:

- Improving criterion-based assessment;
- Improving learning in subjects with large student numbers;
- Introducing flexible learning approaches in targeted subjects.

When fully developed, the *e*-Task system will have the following distinct features:

- *Modular, Multipurpose & Re-usable:* The system is capable of forming a pool of logically organised modules that can be deployed in more than one subject for different assessment purposes. Each module is originated from a parent subject where it is used for in-subject assessment and / or as exercises for learning. It then can be re-deployed in a subsequent subject for diagnostic assessment of prerequisite knowledge or as a learning / exercise module by students.

- *Scalable & Resource-optimal:* The system is independent of class size since it is computer-based and hence it is automated for both marking as well as for collecting student feedback. Individual modules can be used in PC labs of the faculty for supervised summative assessment or they can be distributed online for informative assessment to be completed off-campus.

- *Flexible & Active learning:* The *e*-Task assessment system promotes active learning in targeted topics considered to be difficult. This is achieved by practice modules which can display hints, partial solutions, informative feedback and references to learning materials. Students will be able to attempt each exercise module as often as needed and obtain timely feedback on their learning progress which in turn assists them to independently bridge prerequisite knowledge gaps and thereby gain confidence and become active learners. Monitoring students' learning progress will also enable lecturers to timely adjust their teaching accordingly.

System Features

The *e*-Task assessment and feedback system being piloted has been developed using a standard spreadsheet program, whereby one or more tasks can be grouped inter-dependably in the same workbook. Each *e*-Task deploys two versions to students: a practice (exercise) version and a test (quiz) version. As will be explained later, the test version has an inbuilt student survey instrument for collecting information on students' perception of their learning. Students can download both versions from the subject website; however, the test version can only be opened by entering a valid student number. Figure 1 depicts the layout of a typical *e*-Task problem in practice mode and Figure 2 shows the example of a different *e*-Task in test mode. Both *e*-Tasks were taken from the subject Structural Analysis. In the example of Figure 1 the *e*-Task exercise to be completed is presented within one of the visible worksheets. Other worksheets and VBA macros that contain the solution are intentionally hidden from students. The circled numbers in Figure 1 point to the following *e*-Task features: A set of parameters that define the problem (1), which can be replaced on demand by a new dataset by pressing button (2). Each new dataset is generated at random but within predefined and meaningful limits defined by the lecturer in a hidden worksheet. The student attempts the problem by entering his / her solution in the designated place (3). In practice mode immediate feedback comments and marks earned are displayed as each part of the solution is entered (4). Upon request, the practice mode can also generate pre-programmed solution hints (5) and correct numerical answers to part or all of the solution (6). Such help, if requested launches a dialog box (7) that gives the student the choice of which part of the solution should be revealed and also to display the corresponding mark to be deducted if the student accepts the help.

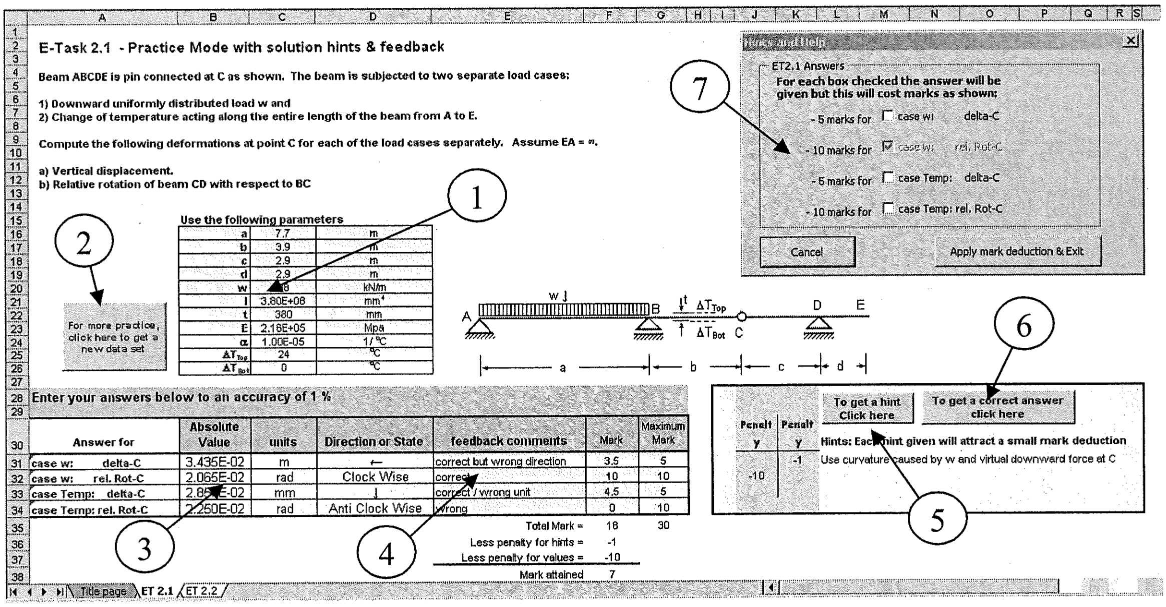

Figure 1: e-Task in Practice Mode

An advantage of the spreadsheet platform is the relative ease with which new exercise problems can be prepared. Depending on the degree of difficulty, the authors estimate approximately 4 to 6 hours preparation time, which includes the time to set up the text and graphics describing the exercise, identifying the solution parameters, deriving solution formulas in terms of those parameters and entering those formulas in the spreadsheet. For complicated formulas or when a solution requires multiple steps, a user defined function can be programmed in Visual Basic. Naturally, the solutions are placed in an area of the spreadsheet which is hidden from the student and secured by a password.

Figure 2 shows the *e*-Task in test mode using a different problem. In test mode each student is given a fixed unique data set (1) which is generated based on his / her student number. The student enters the results in the designated area (2). Marks attained are displayed (3); however hints and partial solutions are not provided. As part of the *e*-Task's test mode students are required to complete a set of short survey questions (4) which they answer by making selections from pull-down menus. The survey questions are designed to give timely feedback on student's perceived learning and thereby assist in enhancing teaching quality. After the submission deadline, student marks are collected automatically by a separate spreadsheet program, which also collects and displays the survey data as shown in the examples (5).

Pilot implementation and student feedback

The *e*-Task was pilot tested in the subject Structural Analysis in Autumn 2010 by using it as a practice tool for students to prepare for in-class quizzes and also as replacement of handwritten assignments. The pilot implementation consisted of four *e*-Tasks distributed throughout the semester and timed to coincide with student preparation for in-class tests. In the last week of semester, 75 students who attended the lecture were asked to complete a paper survey on their experience with the *e*-Tasks. The survey was a mixture of types of questions including Likert scale and open-ended questions. The survey questions were aimed at establishing the *e*-Tasks' effectiveness in motivating students to study and to facilitate their learning and preparation for exams in the subject. The responses to the survey were collated to provide the frequency histograms shown in Figures 3 – 6. Two open-ended questions were also included on the survey instrument. These were: i) *The three best aspects of the e-Task are*: and ii) *The e-Task could be improved by*. Not all students surveyed provided a response to these questions; 92% of respondents provided a 'best aspect', and 88% of respondents provided some indication of how the *e*-Task could be improved. These responses were examined for recurring themes as described by Tucket (2005) and Braun & Clarke (2006). In an attempt to establish the important issues relating to the use of the *e*-Task as perceived by students, the themes were derived from the responses and were not pre-determined by the authors. The results of the thematic analysis to the open-ended questions are presented in Tables 1 and 2. The themes are listed in order of prevalence as indicated by the % of respondents who mentioned that theme.

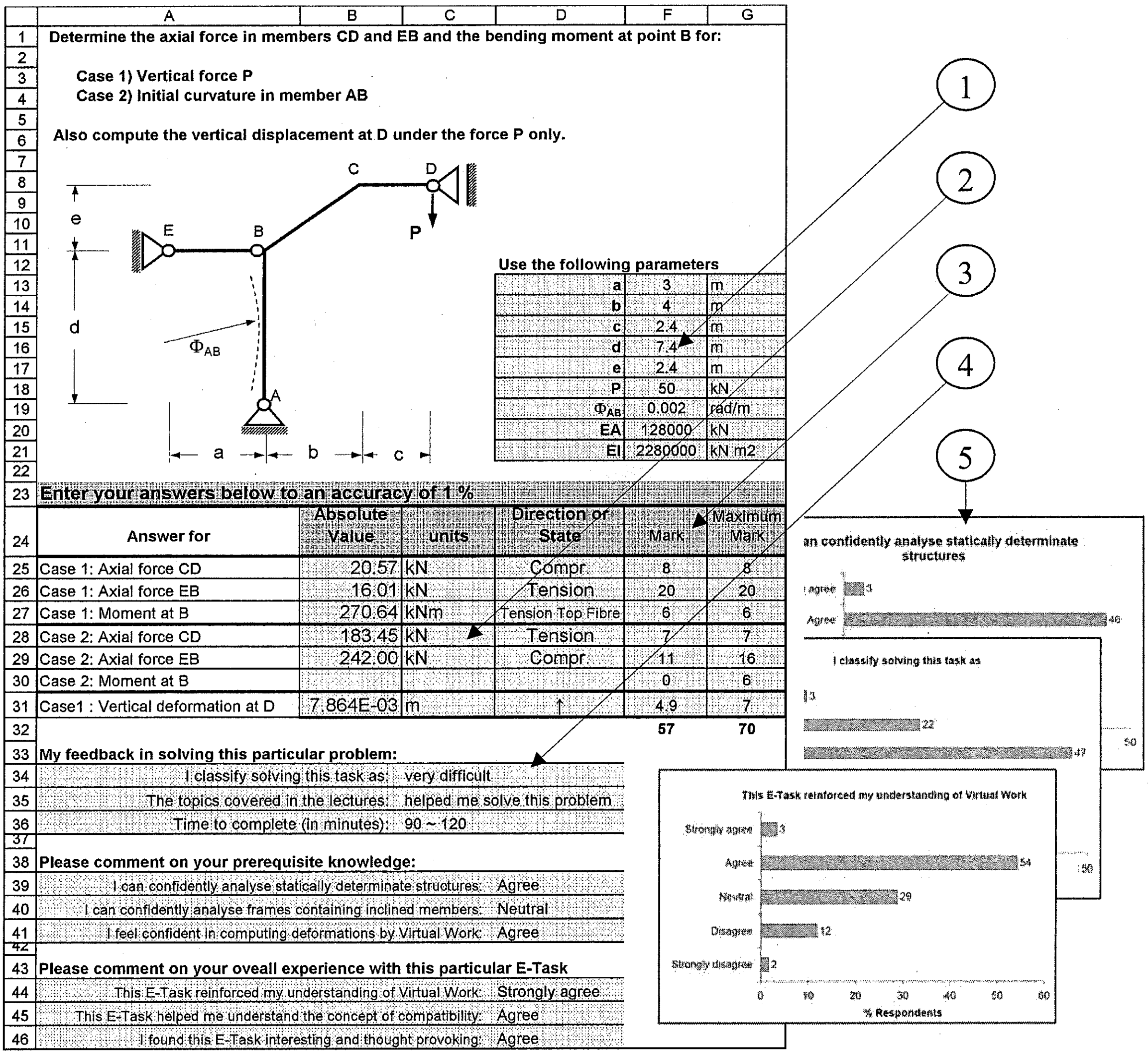

Figure 2: *e*-Task in Test Mode

The responses presented in Table 1 indicate that the most often referred to themes regarding the best aspects of the *e*-Tasks are their usefulness in subject revision and preparing for exams, their challenging nature and the feedback on learning progress provided by the *e*-Tasks. Further important themes were that *e*-Tasks helped students to better focus on their study and that students perceived the *e*-Tasks as a fair method for assessing their work.

The themes identified in Table 2 on how the *e*-Tasks could be improved show that the most prevalent themes relate to reducing their degree of difficulty, developing more *e*-Tasks, discussing solutions in class and providing more and better solution hints. Interestingly the comments relating to reducing the degree of difficulty seem to contradict the comments in Table 1 where students listed the challenging nature of the *e*-Tasks as a 'best aspect'. The authors believe that improvements recommended by students to reduce the degree of difficulty and to provide worked solutions relate to how the *e*-Tasks are integrated into the subject, rather than the *e*-Tasks themselves.

Figure 3 indicates that most students agreed with the statement: "*e-Tasks motivate me to study and focus on my learning more than traditional hand written assignments*"; whereby (13 %) strongly agreed, (32 %) agreed, while a further 26 % slightly agreed with the same statement.

Table 1: Responses to the question: The best aspects of the *e*-Tasks are:

% of respondents commenting and the corresponding theme		Typical student comments
34 %	Preparation for quiz / exam	"It helped me prepare for my in class test"; "Similar to the type of questions your would find in an exam"
26 %	Degree of difficulty	"Fun & Challenging"; "Forced you to think"; "If you attempt them they are very challenging pieces of assessment so you try to learn"; "Difficult so I knew if I could do it, I can do an exam question well."
23 %	Revision / exercise	"Great revision helped understanding of concepts "; "Helps for working through a question for each subject from beginning to end"
21 %	Feedback on learning progress	"Practice mode enabled me to make sure I know what I'm doing is correct."; "Ability to see if correct answers or not, confirmation of understanding."
19 %	Focus on study	"Helped me to focus on what I should study"; "Force students to study on a regular basis, similar materials are presented in lectures"
11 %	Feedback	"Instant Feedback"; "quick and efficient"; "We could check our answers straight away"
9 %	Fairness	"Good learning experience for those who don't cheat"; "Different numbers for each student meaning harder for people to copy"

Table 2: Responses to the question: The *e*-Tasks could be improved by:

% of respondents commenting and the corresponding theme		Typical student comments
30 %	Making *e*-Tasks less difficult / less time consuming	"Some questions were very difficult"; "Could make it less time consuming"; "Sometimes to difficult and time consuming given the mark allocation "
18 %	Developing more *e*-Tasks	"More *e*-Tasks exercises could be useful"; "More questions"; "Better having more frequent easier tasks"
18 %	Working through the solutions in class	"Working through the solutions once the e-task due date has passed"; "Answers gone through in class"; "Provide complete methodical solution for *e*-Tasks after due date"
13 %	More / Better hints	"More guidance in the questions"; "More hints in the practise task "; "More useful hints"
13 %	Numerical values of used in solution.	"Use round number parameter (distance, force)"; "The numbers are too fiddley"
12 %	Compatibility of Spreadsheet	"Compatibility with windows 2007 and Mac"; "Making it accessible on all versions of Excel rather than just the earlier versions";

As shown in Figure 4, almost 80% of respondents used the practice mode of the *e*-Task before attempting the test mode of the same problem for which they were being assessed. The most common number of times the practice mode of the *e*-Task was used was once (37%) and 2-6 times (41%).

The results of Figure 5 confirm that by allocating a unique data set to each student the issue of plagiarism is addressed, whereby 47% of respondents agreed that they were forced to complete the *e*-Task by themselves, with further 12% and 21% respectively strongly agreeing and slightly agreeing with that statement. The responses shown in Figure 6 confirm that all things considered, most students found the *e*-Task a good learning and assessment approach with 55% agreeing and a further 9% strongly agreeing.

In summary, most student feedback was positive and indicates that the *e*-Task has achieved the desired objectives stated earlier.

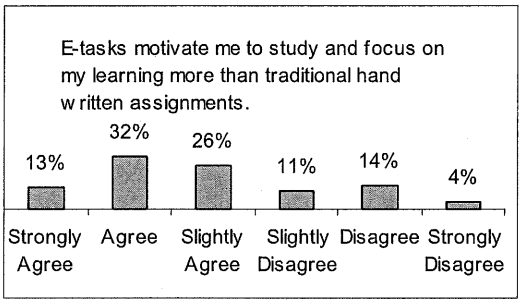

Figure 3

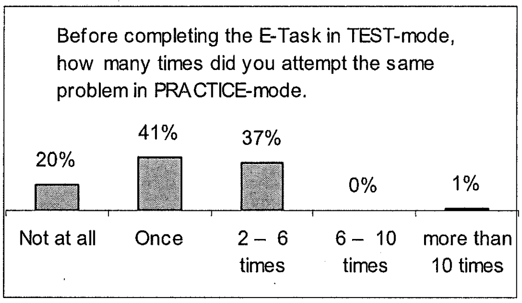

Figure 4

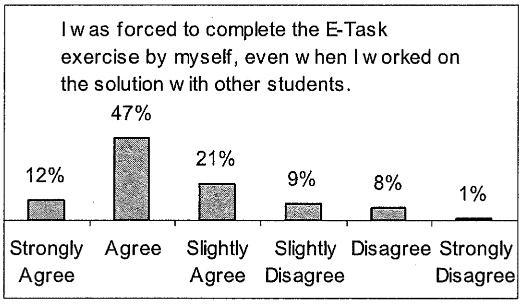

Figure 5

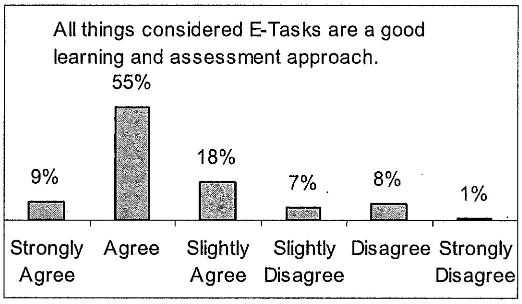

Figure 6

Conclusion

This paper presents the development and pilot implementation of an innovative computer-based assessment and feedback system for structural engineering education, namely *e*-task. The system developed aims to be formative, diagnostic, developmental and summative. Based on experience gained from a pilot deployment of the *e*-Task in the autumn semester 2010, it was found that use of the *e*-Task has improved student motivation to study and to focus on their learning more than traditional hand written assignments. In a paper survey, students commented positively on the immediate feedback on their learning progress which the *e*-task system provided. The inbuilt survey instrument gives the lecturer timely and valuable feedback on student learning. The positive results lead the authors to recommend the continued development of the *e*-Task system.

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References

Bourne, J., Harris, D. & Mayadas, F. (2005) Online Engineering Education: Learning Anywhere, Anytime. *Journal of Engineering Education, JALN Volume 9, Issue 1 — March 2005.*

Braun, V & Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*. Vol. 2, issue 2. pp 77 – 101.

Goldfinch, Carew & McCarthy (2008), Improving Learning in Engineering Mechanics: The Significance of Understanding. *Proceedings of the 2008 AaeE Conference, Yeppoon. Australia.*

Saleh, A., Li, J. & Nejadi, S. (2009) Development and concept proof of an innovative assessment system for effective teaching and enhanced learning in Structural Engineering *Poster presentation*

Tucket, A. (2005) Applying thematic theory to practice: a researcher's experience Contemporary Nurse. *July – August.*

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