Internet-hosted assessment system for effective teaching and enhanced learning for engineering subjects

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Abstract: *Despite of their popularity, online Learning Management Systems suffer serious limitations as a reliable and effective assessment tool in their implementation for engineering education, partly due to their demand for equation manipulation and multiple stage problem solving. An innovative spreadsheet based assessment tool (e-Task) which is designed to overcome such shortcoming and provides effective teaching and enhanced learning for engineering subjects has been proposed by the authors. The tool was developed for both formative and summative assessments with a capability to automatically collect not only results but also feedback from students on their perceived learning. Building on the previous work, this paper presents a further development by introducing a new deployment concept of the e-Task through internet-hosting of the system in order to enable effective teaching and enhanced learning of engineering subjects. The proposed internet-hosted assessment system (e-Task) integrates state-of–the-art cloud computing technology by incorporating a spreadsheet-like environment that can accommodate a wider range of users and course developers as well as enables easier expansion of the system in the future. It greatly enhances the fundamental concepts proposed in the original e-Taks by offering better accessibility, flexibility and controllability. It obviates any need of a specific software or hardware for the operational platform and requires only Internet access for its operation. Features of the Internet hosted e-Task include: the ability to access it by various Internet browsers, embedding learning and diagnostic feedback, individualised data sets for each students and automated marking & feedback.*

Keywords: Engineering education, Assessment and feedback, Internet-hosted assessment and feedback, *e*-Task, ODVLab, LibreOffice

Introduction

The use of commercial on-line course management platforms is now commonplace in most education 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 due to the nature of engineering type problems, which often require equation manipulation and multi-stage problem solving (Bourne et al, 2005, p.15). Developing assessments for this kind of problems often can not be catered for in the online assessment tools of general purpose Learning Management

Systemss 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.

To address this shortcoming and to complement existing online assessment tools, a system that uses conventional spreadsheet software was developed and successfully pilot tested in 2009 and 2010 (Saleh, Li, & Nejadi, 2009) and *(Saleh & Li, 2010)*. The spreadsheet was chosen over other platforms because it is readily available and familiar to most potential users including course developers. The system, referred to as *e-Task*, offers great flexibility for preparing a wide variety of assessment options and enables the setting and deployment of high level engineering assessment problems which can be considered as developmental, formative and diagnostic.

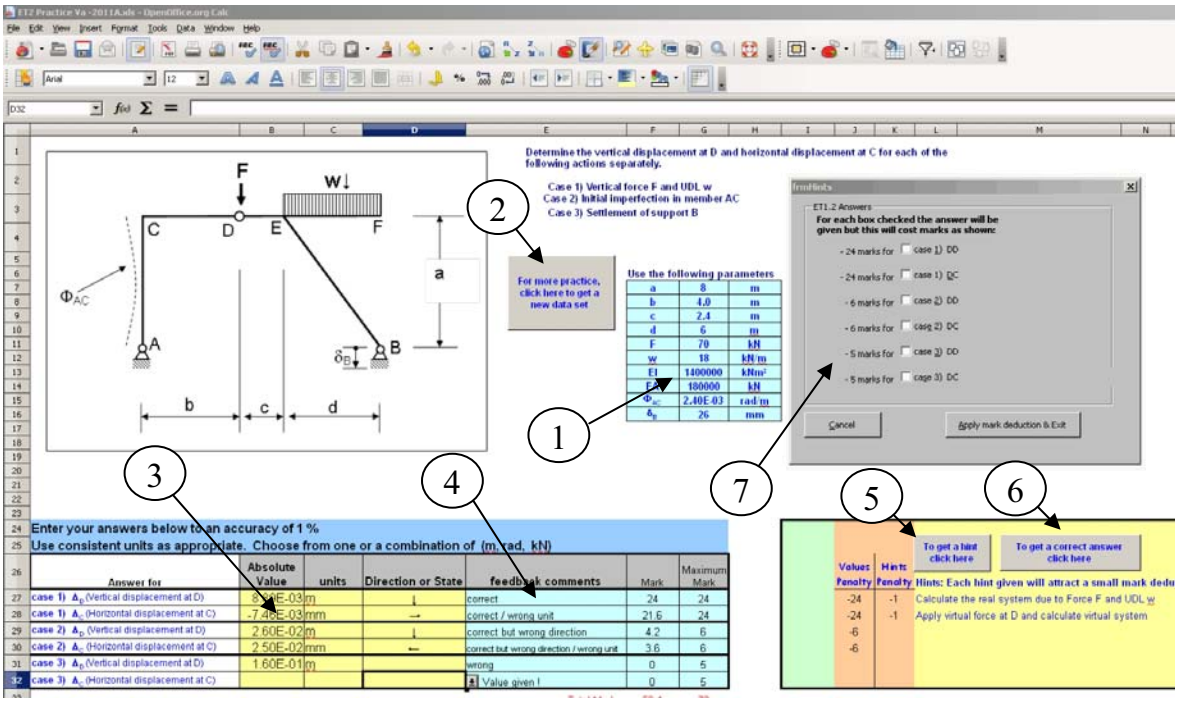

Figure 1: Example of a typical e-Task using internet hosting

The original *e-Task* concept was to distribute a pre-prepared and password protected *e-Task* spread sheets (in Microsoft-xl 2003) to students. Students then open the *e-Task* using a PC and return the completed spreadsheet for automated marking. By entering the student ID, each student obtains a unique data set for solving the given assessment task. It is also possible to activate the *e*-Task in practice mode, whereby at the press of a button a random data set is generated. Naturally each dataset is generated within predefined and meaningful limits defined by the lecturer in a hidden worksheet. One or more exercise(s) or assessment task(s) can be grouped inter-dependably (per spreadsheet) in the same workbook allowing complex problems to be broken down and solved/assessed in a multiple stage fashion. As a diagnostic tool to assist the lecturer, it is also possible to include an inbuilt survey instrument for collecting information on students' perception of their learning as well as statistical data on students' performance which can be itemised as required (such as units, errors in sign, or a particular concept). A typical example of an *e*-Task is shown in Figure 1. 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 randomly but within predefined and meaningful ranges 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. This feature is also possible to be further developed into a learning tool that provides guidance (leading to contents in lecture materials/text book) and learning diagnosis for students.

As was reported in the pilot study by Saleh & Li, 2010, it was found that use of the *e*-Task improved student motivation to study and to focus on their learning more than traditional hand written assignments. The inbuilt survey instrument also gives the lecturer timely and valuable feedback on student learning. More importantly the *e*-Task, with its multiple stage approach, gives the flexibility for future innovative design of assessments that provide progressive learning and encourages thinking.

Motivation

The development of the original *e-Task* was driven by the need for an innovative assessment and feedback tool to improve the quality and capacity of teaching practices and enhancing student learning outcomes in engineering education. The *e-Task* developed originally as a stand alone system was aimed at i) improving criterion-based assessment and feedback practices; ii) improving learning in subjects with large student numbers and iii) introducing flexible learning approaches in targeted subjects.

The originally developed innovative feedback and assessment system, i.e. *e-Task*, was designed to have the following distinct features:

1. *Modular, Multipurpose & Re-usable:* Through a pool of computer based modules categorised by topic, the system can be easily deployed in related courses for different assessment purposes. Each module is originated from a parent subject where it is used for primary assessment and / or as learning exercise. It then can be re-deployed in other related subjects as assessments for revision and diagnosis as well as for self-learning to bridge gaps in prerequisite knowledge.
2. *Scalable & Summative / Informative:* Independent of class size since it is computer-based with automated marking / feedback, the system can be used as summative assessment (in PC labs with supervision) or as informative assessment to be completed off-campus.
3. *Flexible & Active learning:* Promoting active learning in targeted topics especially those considered to be difficult to learn, the system allows innovative design of modules, especially with the practice module, providing guidance, informative feedback and references to students. For difficult topics, students will be able to attempt each exercise module as often as needed. Through repetition and timely feedback of the online exercises they can bridge prerequisite knowledge gaps on their own and hence gain confidence and become active learners. Monitoring students learning progress will also enable lecturers to timely adjust their teaching.

During the pilot implementation of the stand alone *e-Task*, it was found that PC platform with MS excel® has seriously jeopardised some of the aforementioned features of the *e*-Task system for the following reasons. The use of conventional spreadsheet software with password protection does not guarantee the security of assessments. Some students were able to bypass or unlock the protection with relative ease and hence gained access to the solution of the assessment task. A higher degree of controllability was therefore necessary in order to ensure fairness of assessments which would otherwise hinder the learning. Accessibility and flexibility of the stand alone PC based *e-Task* system was also a serious issue. Accessibility can be limited by the availability of a platform that is compatible with the platform on which the *e*-Task was developed. For example, not all student users have access to the windows based PC platform on which the *e-Task* was developed (such as MS excel 2003). Furthermore, some students use Mackintosh computers, while other students who have a windows operating system may not have MS excel or have different versions of MS excel. Version compatibility was also identified as a serious maintenance issue, whereby the *e*-Task system, has to be

continually updated to keep up with users upgrading their spreadsheet software to the latest release on the market. Moreover, many of the aforementioned features and the potential for further expansion of the *e*-Task were found to be limited by the stand alone nature of the PC platform.

An obvious solution to the above mentioned issues was to utilise cloud computing technology by replacing the standalone *e*-Task platform with one which is internet hosted. Such an option would also be appealing to today's students who perceive such web based technology as attractive. As will be described later, internet hosting of the *e-Task* not only provided a high degree of security but also enabled students to access the *e*-Task from various platforms including PC, Mac and iPad.

Development of Internet hosted *e-Task*

The internet hosted *e*-Task system is made up of a web portal and a pool of virtual machines that provide the virtualised application. These virtual machines are provided by the faculty's On-Demand Virtual Labs (ODVLab). For each user the *e*-Task software runs on one of the virtual machines, the students view this software through the remote application protocol NX.

In order to transfer the *e-Task* from the original PC based system to the internet hosted system, the following developments were implemented:

The Microsoft Excel spreadsheet was replaced by the open-source office suite LibreOffice. This required only minor adjustments as LibreOffice can read and convert most conventional spread sheets including VBA programming codes. Hence users can continue to setup the assessment task on Microsoft spreadsheet and easily convert it to LibreOffice. The open source implementation of NX, NeatX, written by Google was chosen to provide the remote access to LibreOffice.

The web portal is a small application that was integrated into the faculty's student intranet. Based on student enrolments and the current date/time it would allow access to the relevant *e*-Tasks. This allowed multiple *e*-Tasks to be delivered within a single subject and also to simultaneously host *e*-Tasks for multiple subjects. Students only required an internet browser and Java.

The internet hosted *e*-Task system can keep track of when students attempted an *e*-Task thereby providing a mechanism to monitor the study patterns of the students. It provided a feedback mechanism of when a student first attempted, how often they attempted and the duration of attempts and also when they last attempted the task.

The pilot system was developed over 4 assessable items in a subject over a period of a semester. For each trial we were able to monitor the technical limits of the system including scalability, usability and support processes.

Initial trials of the internet hosted system revealed that there is a need for a load balancing algorithm in order to cater for peak periods of student usage, which tended to increase 12 hours before the task was due and peaked in the period of 6-8 hours before the due time. In normal periods of use the system was able to support up to 20 simultaneous users using the software per virtual machine however during peak periods when students were more actively using the software this decreased to 7-10 users per machine. The load balancer along with the provisioning services of ODVLab allowed more virtual machines to be turned on during peak periods and to turn them off again once the assessment was complete.

Pilot implementation and testing of Internet hosted *e-Task*

The first implementation of the internet-hosted *e-Task* system was pilot tested in a class of 160 students during the 2011Autum semester using four *e-Task*s worth approximately 10%, in which each *e*-Task was accompanied by its practice module. The *e-Task*s were issued once every 3-4 weeks which allowed time to establish and as necessary to fix teething problems by gradually improving the system. Although a systematic survey and analysis are yet to be conducted, the following observations have been made.

Based on informal comments made by students, it became apparent that students engaged more deeply with the technical contents of the subject. In completing the *e*-Tasks, the plagiarism has virtually been eliminated as every student had an individual data set to work with and web host security made it almost impossible to bypass the protection system. The exception was that in some isolated incidents, a student might ask a fellow student for help to complete his/her task. However, if it is required the *e*-Task can be run as supervised summative assessment.

It was possible to easily monitor student study patterns, which revealed that the majority of students attempted the *e*-Task very close to the submission deadline. This generated a peak demand causing the computing system to crash repeatedly at the first *e*-Task. The further development of a load balancing algorithm in order to distribute the usage among several computers has successfully resolved the problem.

Conclusion

This paper presents the development and pilot implementation of an internet-hosted *e*-Task assessment system which is modular, multipurpose & re-usable, diagnostic, scalable and flexible. It encourages active learning by being formative, developmental and summative. Based on a pilot implementation, the system demonstrated the ability to provide access flexibility without the demand for a specific software or hardware platform while maintaining a tighter control on user access and ensuring high security and protection to the assessment against plagiarism. At the end of the pilot deployment, the system was able to cater for a class of 160 students.

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