Int. J. Engng Ed. Vol. 22, No. 4, pp. 839–848, 2006
Printed in Great Britain.

0949-149X/91 $3.00+0.00

Evaluating Online Testing Technology*

SEBASTIAN A. MAURICE
Faculty of Engineering, University of Calgary, Calgary, Alberta, Canada, T2N 1N4

SHELLEY LISSEL
Faculty of Engineering, University of Calgary, Calgary, Alberta, Canada, T2N 1N4
E-mail: smaurice@ucalgary.ca

This study reports results on how design aspects of technology and perceptions of students towards online testing technology affect the learning and preparation process of students. It follows a previous study conducted by Maurice and Day who found that students generally disliked online testing technology due mainly to design and performance of the technology. Using the recommendations from the previous study, the authors redesigned the online testing technology. The purpose of this study is to evaluate the redesigned online technology and show whether the recommendations made by Maurice and Day had a positive impact on students with respect to access to and use of the new testing tool. Using data from a survey completed by 157 university students in an undergraduate engineering course, we present a summary of their feedback on whether the redesigned online testing technology was an effective tool in helping them learn the course material and a good preparation for exams. The results in this paper are compared with the results in the previous paper. Our results show that the changes made to the online testing technology, as recommended in the previous paper, did have a positive impact on the students. Specifically, student feedback was much 'nicer' than in the previous study. Our results validate the recommendations in the previous paper—at least in the present sample. We also present an instructor's view and experience with the new online testing technology. The instructor's experience with the new online testing technology was also positive.

INTRODUCTION

THE FACULTY OF Engineering, University of Calgary, has been using an online testing technology in a large undergraduate course with over 600 students. This paper evaluates the redesigned, or new, online testing application (OTA) based on the recommendations made in [1]. The aim of the present paper is to show whether implementing the recommendations made in [1] have had a positive impact on the learning experience of students. We want to answer the question: 'Did these recommendations have the intended effect once implemented?' We present additional experiences, challenges, and successes faced by students using this *new* online technology, gathered from a survey, shown in the Appendix, of over 600 students in an engineering undergraduate course. This paper also presents the views of an instructor who taught this course; these views are presented in order to understand if this online testing technology had an impact on the lecturer's teaching and how it influenced their interaction with students—if at all.

This paper is organized as follows. We present a background explaining the previous study. The implications of online testing technology are explored. This is followed by an explanation and evaluation of the new online testing technology. Following this is a section that explains the data collection procedures from a survey, shown in the Appendix, completed by over 100 students, and presents the results. This is followed by a section that presents an instructor's view of this technology and sees whether it had an impact on their teaching and interactions with their students. The paper concludes with a discussion, the lessons learned, and conclusions.

BACKGROUND

Maurice and Day [1] conducted a study of an online testing system that was used in their faculty. The purpose of that study was to examine if online testing technology was an effective tool to encourage students to learn the course material, so that they will be better prepared for exams and to extract the lessons learned. Using survey results from 285 students in an engineering undergraduate course, the authors got very interesting results. Generally, students disliked the online technology for several reasons. Many did not like how the application interacted with their desktop and some dreaded the feeling of losing control of their desktop. Others felt the system was too rigid and many did not like the 'countdown timer' [1]. From student responses, Maurice and Day made recommendations that would improve the online testing technology. These recommendations were used to redesign the online technology, specifically the user

* Accepted 14 March 2005.

interface shown in Fig. 1, and evaluate its performance on a new sample of students. This paper presents the results of this evaluation.

IMPLICATIONS OF ONLINE TESTING TECHNOLOGY

Several studies have shown the importance and positive aspects of online testing technology as they relate to teaching and learning [2–5]. Specifically, online assessments allow instructors to use a test bank of questions and deliver these questions at random to students instead of creating questions from scratch [3]. Online assessments allow instructors to determine what concepts or questions students had the most difficulty with and to concentrate lecture time on these. Instructors can use less class time for quizzes and save time and resources by having the computer grade quizzes [4]. Technology can also allow for multimedia content (video, audio, graphics) interactivity [5]. Instructors can control access to quizzes [2] and also have the option to give students the flexibility of being able to retake online quizzes at their convenience [4]. Online assignments also have the potential for improved learning [3] and have the advantage of being able to provide immediate feedback to the user; students not only know what their grade is but where they can get more information on the subject matter [3–6]. This allows students to monitor and track their progress, which contributes to increased learning.

Some notable disadvantages of online testing technology are that online assessments take more time and effort to prepare [3, 4]. Also, most students only participate in online assessments when it is mandatory to do so. Even when students felt that online assessments helped them to prepare for exams, they would only use them if required [4]. Students can be encouraged to work independently by putting a time limit on questions, using the assessment as a self-learning tool, or using parametric questions which will generate unique quizzes for each student [7]. Other security issues, such as students accessing questions before the test is made available to all students, or the inability to guarantee the identity of the test taker, can potentially pose problems but these exist for paper tests as well. The only way to minimize these problems is to implement tighter controls in the quiz process, such as issuing passwords to students, verifying students' ID numbers, etc. While the possibility of unwanted behaviour will always remain, these suggested measures can minimize their adverse impacts. Other issues, such as technical skill level of users and disability issues, may require additional effort by instructors, but it is expected that these situations will be rare [6, 8]. While the disadvantages can be seen as obstacles to the successful implementation of online technology, the survey results summarized below suggest that the benefits outweigh these costs. Moreover, the new testing technology, in addition to incorporating the recommendations in [1], provides solutions to some of the disadvantages.

THE NEW ONLINE TESTING TECHNOLOGY

The new online testing technology to be evaluated in this paper is web-based (contact: smaurice@ucalgary.ca). For more details on the set-up of this technology and the issues that brought about the present system (Fig. 1), see [1]. The fact that it is web-based immediately addresses and rectifies the accessibility issue. Many features are the same as on the older Windows version shown in [1]. The main differences from the old version are the following (the numbers correspond to the numbers in Fig. 1):

1. Students can now jump to the question of their choice, without having to move sequentially between questions, by entering the number of the question and clicking the middle button.
2. Shows the date/time they last performed an action on the system—this helps to show them when they did something and confirms that their action has been received by the server.
3. The timer has been completely removed.

Further to the above changes, the system now has two modes of testing: assignment and testing modes. The assignment mode does not have a test deadline, meaning the students can complete their assignment any time they like as long as it is within the start and end times set by the instructor. So during an online assignment the student can stop the assignment and tell the system to save his or her work for a later time. When a student returns the next day or some other time, they can continue with this assignment. The flexibility of the assignment mode has been very successful with our students. While the test mode is still operational, we have completely removed the timer. As we learned from the previous study, students do not like a countdown timer as it is distracting and intrusive—this is also consistent with the findings in [6]. We have also removed the 'Sound off' button because there is little need for sound when doing an assignment.

We have drastically improved our training methods for both students and instructors [9]. In the first week of lectures, the instructors hold tutorial sessions that explain the functions of the system with an online demo of the system. The online system support information is given out and all the details of the online system are also indicated on the course website, in an effort to minimize confusion about 'where to access it', 'how to access it', and 'when to access it'. Students get an opportunity to ask questions about the system. We have found that this information session with an online demo helps to re-assure students about the accessibility and stability of this system. It

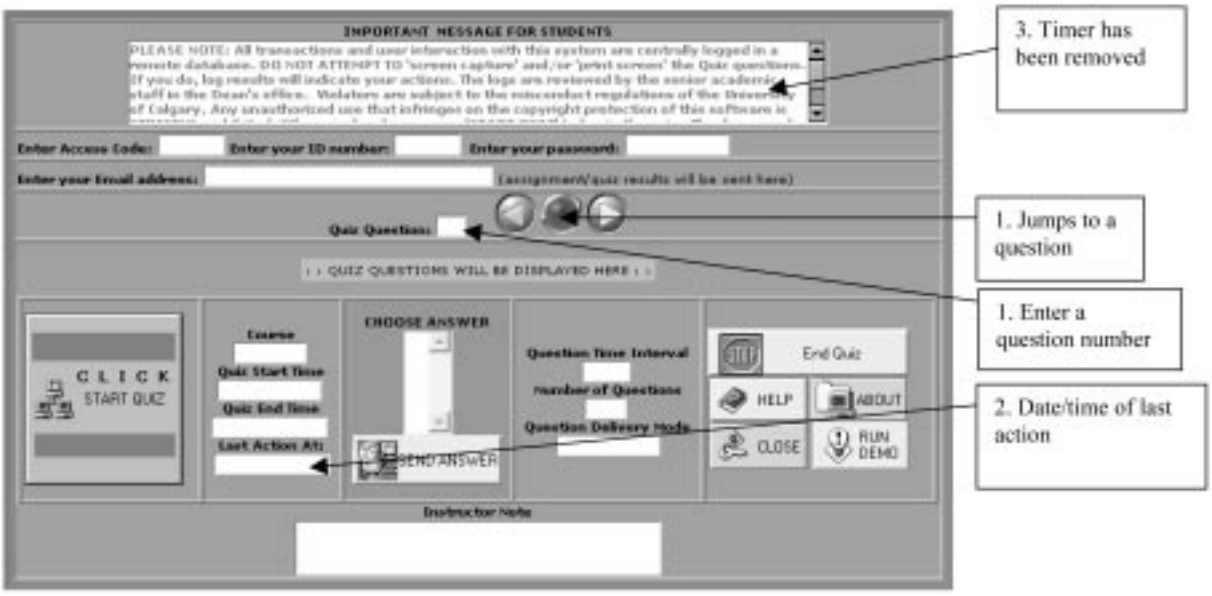

Fig. 1. The online testing technology.

was clear from the previous study [1] that accessibility and stability were critical to the success of this system. Also, since the new online system is now web-based, it is also platform-independent, which means that students using Mac and Linux can now easily access and use the system. In the previous study, MAC users complained that there was not a MAC version [1].

One of the internal features we have added is the ability for instructors to include video and audio in their quizzes or assignments. While this has yet to be implemented by any instructors, mainly because of bandwidth limitations, it is only a matter of time before assignments and tests incorporate audio and video components in the questions and choices. The inclusion of video and audio components should help to enhance learning [1, 6, 10].

In an effort to implement this new testing technology (Fig. 1) at the University of Calgary, there were a few hurdles that we had to overcome. First, we had to convince instructors that online testing could be an effective teaching tool for their classroom, and second, we had to convince students to use it. Many instructors were concerned about the stability of the online technology, mainly because of the failure of the old system discussed in [1]. They did not want stability and access to pose a problem for students. In order to convince instructors, we tested the technology on their students in a non-grading situation. Students were given a tutorial on how and where to access the test. Several tests were run and no major issues arose. Instructors particularly liked the automated grading and the parametric nature of the questions. Issues that were present in the old system [1] were rectified in the new web system. Students were easier to convince once it was made clear that the online testing component would carry a weight towards their final course grade and so using the system was mandatory if they wanted to receive a grade for this component.

IMPLEMENTATION OF THE ONLINE TESTING TECHNOLOGY

Figure 2 illustrates the Quiz system process and summarizes the implementation of the Online Testing Application (OTA) as follows:

Steps I–II: Instructors enter the quiz questions on a secure website—which is then stored in a secure quiz database.

Step III: Students then go to a student access website to access the OTA.

Step IV: The OTA then connects over the internet to the server quiz application (SQA)—and the quiz begins. All communication between the OTA and SQA is encrypted.

Steps V–VI: the SQA automatically marks all quiz questions and stores them in the quiz database. Immediately following the completion of the quiz, the OTA presents the student with his/her grade. The SQA automatically e-mails the student a detailed explanation of their quiz results, such as the questions they answered correctly or incorrectly.

Both instructors and students access the online system via the internet. Instructors access the system through an instructor website: a username and password is assigned to them by the system's administrator. After the instructor has 'designed' the questions and the multiple-choice options, he or she creates the online quiz by setting the 'rules' for the quiz/assignment, including dates and times that it will be accessible by students, whether it should be in test or assignment mode, and so on. After setting these parameters, a unique access

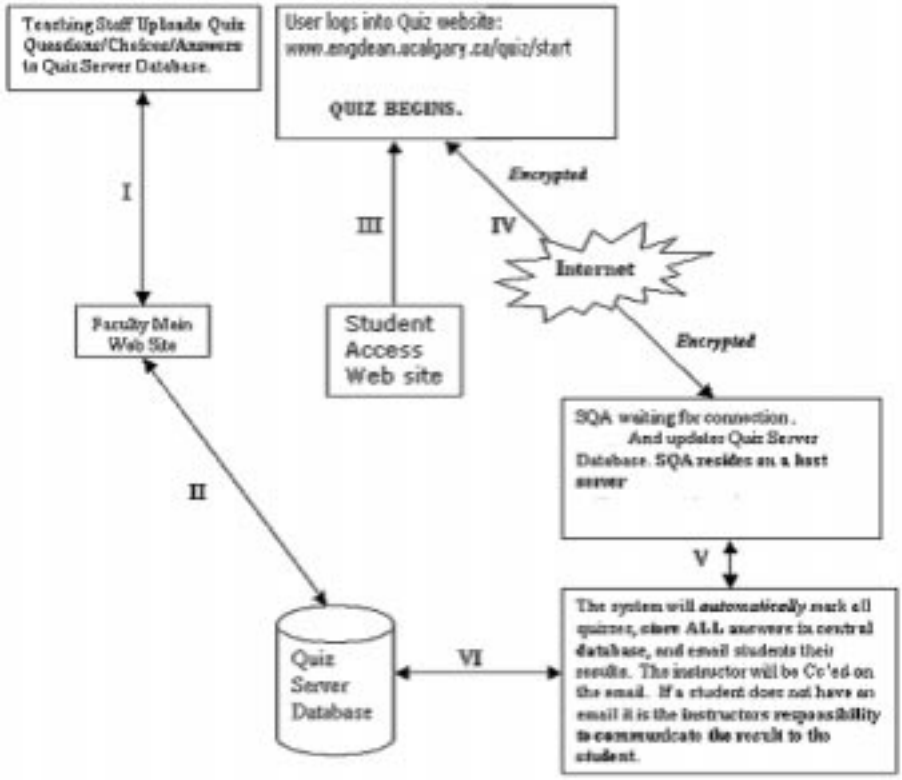

Fig. 2. The quiz system process.

code is assigned by the system and the instructor may upload his/her questions to the quiz system. The unique access code is the key to this particular quiz and the instructor must inform his/her students of the access code in order for them to access the quiz. For more details on how questions are entered, see [7]. Note that, from the survey results discussed below; quite a few students had some concern with the quality of the questions themselves in terms of the wording, the graphics, the choices, the significant figures, etc. So the 'design' aspect of the online quiz process is quite important and significant effort needs to be expended at this stage to design good multiple-choice questions. 'Translating' the questions using the Excel spreadsheet to be uploaded to the quiz system is quite straightforward if the initial question design is done carefully. For example, the instructor must ensure that the parametric nature of the questions will not result in non-logical answers or two answers that appear too alike for the student to make a distinction. The Excel spreadsheet has a test button that the instructor can use to randomly generate sets of numbers and see what answers come out, but this process is somewhat tedious. The instructor is also advised to perform a trial of the online quiz in order to view it as the students would see it.

In order to access the system, students go to the Student Access Website and choose a password using their student ID number as their user ID. Once they have completed this step, they are ready to begin the quiz. Students start the online quiz by entering their log-in information and quiz access code at the quiz access site. The quiz begins once the student has entered all required information and clicks the 'START QUIZ' button (see Fig. 1). The system processes each quiz by using the algorithm in [7]. Each student will receive a unique quiz using the parameters specified by the instructor [7]. Students navigate through the questions by using the forward and backward arrows to advance or go back one question at a time, or they can jump to a question by entering the question number and clicking the middle circle button. Students select their answers and use the send button to submit their answer for each question. Since this is a multiple-choice system,[1] the student's answers are marked immediately after the 'SEND ANSWER' button is clicked, though students are not informed of their results until after they have completed and submitted the quiz. Note that a student must submit at least one answer in order to have 'ownership' of that particular quiz with that particular set of numbers. In assignment mode, students may answer only a few questions in one session and return later on, in which case they will get the exact same quiz they had before. In any mode, students may change answers to a question by selecting a new answer and pressing the 'SEND ANSWER' button once more. When a student clicks 'END QUIZ' there are two options: to

[1] We are in the process of adding an option to allow for non-multiple-choice questions: i.e. short-answer questions.

Table 1. Average survey results from 157 students

Question	Variable	Average Response	Confidence Interval For Mean (95%)	Variance
Ease of accessing the quiz system	EA	3.95 (was 2.24)	(3.78, 4.12)	1.07
Ease of use of the quiz system	EU	4.05 (was 2.30)	(3.89, 4.21)	0.94
The online quiz helped me learn the course material	LEARN	3.57 (was 2.22)	(3.39, 3.75)	1.19
The online quiz helped me prepare for the type of examination questions on the midterm and final examination.	PREPARE	2.93 (was 2.42)	(2.74, 3.12)	1.42
How does the online quiz system compare to in-class paper quizzes? Keeping in mind issues such as flexibility of writing the quiz at your leisure, getting your quiz grade instantly, receiving an instant e-mail detailing the questions you got wrong/ correct, etc.	COMPARE*	3.74 (was 2.54)	(3.55, 3.93)	1.40
Please provide comments below specifically about how you think the system could be improved:	OPEN	Open-ended		

* The COMPARE variable picks up the students' liking or dislike of the technology. If students choose 1, then the system compares poorly to paper quizzes, if they choose 5, it is superior to in-class tests.

save and continue later or to submit their work for grading. In the latter case, the overall results are recorded by the system and presented to the student in the web environment. In addition, an email, which includes what questions the student got wrong and which ones they got right, is sent to the student. All interaction with the quiz system is maintained in a detailed log file. This log file has been very important in addressing student concerns about access and use of the system. All log files, grades, and analysis of the quiz are available to the instructor on the instructor website. The grades are also emailed to the instructor in text file format upon the expiration of the quiz. This makes it very easy to incorporate into the class record book.

Users of this system will notice that it is quite simple to use yet powerful in its processing and managing of the information it receives. Instructors of large classes especially will find this system useful, due to the processing of quiz questions via the unique algorithm explained in [7]. We have found this system and process to be very effective in helping 600+ students learn the course material while minimizing cheating behaviour, addressing students' concerns, and reducing the workload on teaching assistants and instructors [7].

DATA COLLECTION AND SURVEY RESULTS

Over 600 engineering students registered in an undergraduate Mechanics I course in the Faculty of Engineering were invited to fill out a survey over a two-month period. We received 157 responses from students who answered the survey on a website. This survey, shown in the Appendix, asked students questions related to access to and use of the online system, and if this online system helped them learn and prepare for the midterm and final exams. Table 1 shows all the survey questions, as well as a variable associated with the question for easy reference. The average scores received on the survey for the previous version of the quiz system are also shown for comparison.

The results of the survey, shown in Table 1, indicate that, in general, students viewed the quiz process as good, and all results are higher than in the previous study. Meaning, on a scale of 1–5, 1 being poor and 5 being best, and 2.5 being satisfactory, students were more than satisfied with ease of access and ease of use, with average responses of 3.95 and 4.04, respectively. Furthermore, students were also satisfied with the learning and preparation aspects of the quiz system, with average responses of 3.57 and 2.93, respectively. When asked if online testing was better than in-class paper quizzes, we got an average response of 3.74. All of these responses are higher than those in the previous study [1]. The confidence interval for the mean is also shown in Table 1 to indicate that we are 95% confident that the mean, or average, response will lie in this interval.[2] Note the tightness of the intervals, which is evidence that our mean is close to the *true* mean of the population data. The variances are presented for completeness and are small and manageable.

Of the 157 students who answered the survey, 111 also answered the OPEN question. To analyse the results from the OPEN variable we used a survey coding method, as follows. The responses for the OPEN question were scanned for any common themes. These common themes were

[2] We make the assumption here that our data is normally distributed [11, 12].

Table 2. Cluster analysis of OPEN question

	Design	Usability	Access	Functionality	In-class	Overall	Learning
Poor	111	11	11	1	1111111111 111		11
Satisfactory	11	1111111111	1111	11111111		1	1
Good	1111	1111111111 1111111111	1111111111 11111	1111111111 1111111111 111	111111	11111111	11111111

then assigned a code and the responses were grouped according to these codes. The responses were first grouped into summary codes: DESIGN, USABLITY, ACCESS, FUNCTIONALITY, INCLASS,[3] LEARNING, OVERALL. The summary codes were then broken down into subcategories: poor, satisfactory, good.

Table 2 shows that many of the students felt the online system was well designed, easy to use and easy to access. The comments were also examined to identify areas for improvement. Seven students suggested improvements to the feedback from the system. Suggestions included providing feedback after each question was answered rather than providing the results after completion, for the e-mail to report the correct answer rather than just say which ones were right or wrong, and for solutions to be provided. Full solutions were provided for each assignment after the completion deadline but it seemed that some students were not aware of this. Although in general most students (38 comments) found the system easy to use, easy to access, and stable, there were also many suggestions for improving the quiz system interface itself.

Example:

> 'Function wise it's perfectly fine . . . My only beef is it looks like a java script out of a while ago. Is there any way that it could look a little more . . . modern . . . without losing the functionality and simplicity?'

Forty-four (44) students commented on such things as the screen organization and appearance, colours and fonts used, the amount of information required to log in, the lack of workspace around computers, and the desire to be able to print the quiz (in assignment mode) for work in progress and subsequent study purposes. A few students commented that access to computers and/or the internet was an issue, though on-campus facilities were designated for the students in case home access was an issue. Forty-three (43) students provided comments on the nature of the assessment, the majority expressing concerns about not receiving part marks due to the multiple-choice nature of the quizzes.

Example:

> 'Although there is instant feedback etc, etc., I think the online assignments do not reflect the users' knowledge. If an initial answer is wrong, the user is penalized during the rest of the questions that pertain to the initial question.'

This problem will be addressed for the upcoming fall semester by making the questions more independent of each other and possibly by giving part marks for wrong answers that would have been obtained by making a 'small' error. Most students commented that in general the system was a good tool in the learning process, though there were a significant number (18) of comments that indicated the difficulty of the questions did not reflect the difficulty of textbook and exam problems.

Example:

> 'The online questions are too simple and do not prepare us for exams as well as the hand-in assignments do.'

The online quizzes were probably on the 'easy' side; however, as the use of such systems is still somewhat experimental, we did not want to cause too much anxiety with these quizzes and hence they also carried only a low percentage of the course mark. In addition, the questions were asked in such a manner as to lead a student through the solution of the problem, which probably contributes to the impression that the questions were easier. Students also commented on the questions' wording and graphics, which emphasizes the importance of writing *good* questions, as discussed earlier.

We were pleased to learn from the survey results that students *noticed* the stability of the system. Stability of the system, or lack thereof, was a major sore point in the old system [1]. As one student commented: 'Very good stable system, if only Blackboard could be this good!!' Many students also commented on the convenience of the online system. Convenience for students was a major thrust behind the development of the new online system. Students at the University of Calgary are now more mobile and many have part-time jobs, so giving them a way to complete their course requirements without having to come to campus to a specific location has been one of the main positive aspects of the new online testing technology.

[3] If INCLASS is poor, this means that the online system is *preferred* to in-class. Otherwise, if INCLASS is good, then the in-class paper quiz is preferred to the online quiz.

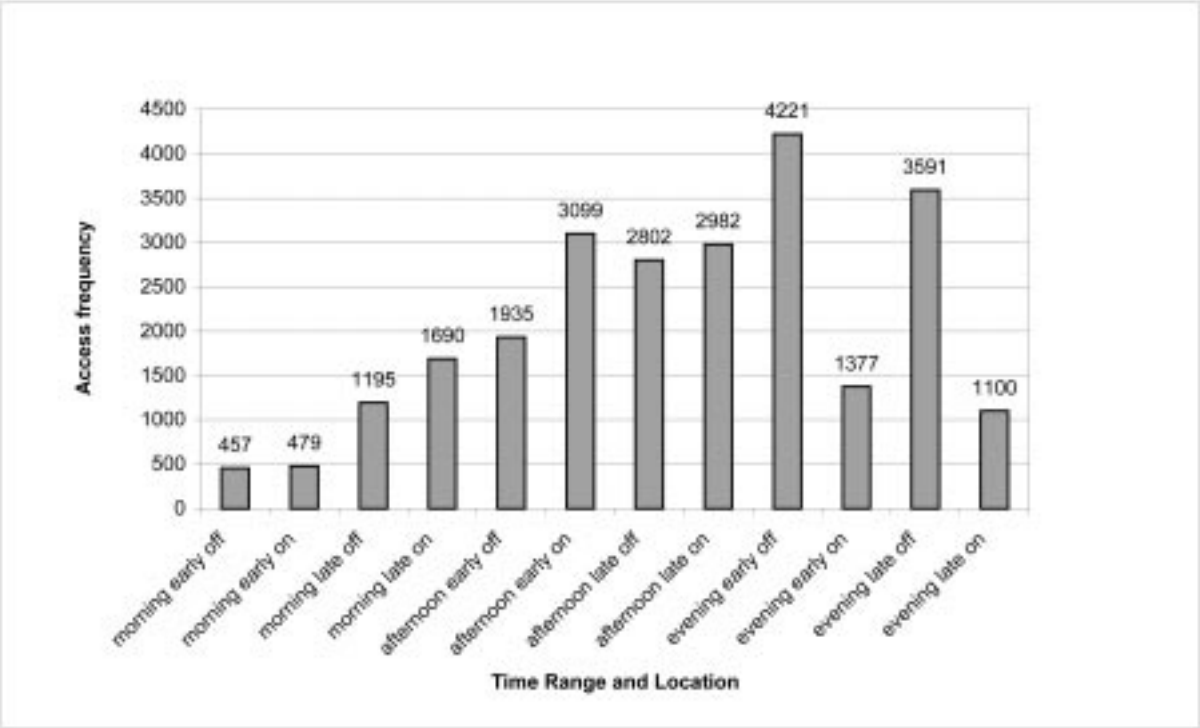

Fig. 3. Online quiz usability distribution.

Examples:

> 'I like the online assignments because I don't have to make the trip down to the university on Sunday night to hand anything in.'
>
> 'I think it's great. I really like getting my mark back right away and being able to do it whenever I want.

Since the students are the end users of this system, the suggestions for improvement that they have provided have been especially valuable and work is continuing to implement the improvements. As one student put it, 'As it stands, the quiz system is more than satisfactory, but like any project or idea, improvements can only increase quality!'

To further illustrate the flexibility of the online system, we analysed user access data to see when and from where students are connecting to the online system to do their quizzes. Specifically, we wanted to see if students were connecting to the online system from on or off campus and at what times. To determine whether the connection was from on or off campus, we checked the quiz logs that keep track of all access to the online system. From these logs we were able to extract the IP address of the incoming connection to the quiz server (which resides on-campus)—since the university network has an IP address starting with 136.159, any IP address not having these first two numbers must be a connection from off-campus, otherwise it is a connection from on-campus. We then checked the time of the connection to see whether it was early morning or late morning, early afternoon or late afternoon, and early evening or late evening. These data are shown in Fig. 3. As Fig. 3 shows, the highest frequency of connections comes in the early evening, between 6pm and 8:59pm, from off-campus. The next highest connection frequency is late evening, 9pm to 11:59pm, from off-campus. As expected, the lowest frequency of connections is in the early morning, 12am–6am, from both on- and off-campus.

This analysis shows that students are indeed utilising the flexibility of the online system. One can speculate that the highest frequency of connections occurs in the late and early evening because students have finished their classes and have gone home. Of course there may be other reasons but the point is that the quiz system is offering students the flexibility to do their tests or assignments when they want and from any place they want; this is a major strength of this online system.

INSTRUCTOR[4] VIEWS

From an instructor's perspective, the online system is a very useful tool and quite easy to implement for anyone the least bit familiar with MS Excel or other spreadsheet programs. One of the obvious benefits is the elimination of the need for marking assignments. In the most recent implementation of the online system in a first-year mechanics course with over 600 students, both online assignments and hand-in assignments were

[4] This instructor, also a co-author of this paper, taught the Mechanics I course in fall 2003 from September to December.

required components of the course Feedback to the students was instantaneous with the online system, while feedback on the hand-in assignments took many man-hours to grade and record the marks. The grading was also sometimes questionable, as TAs are not always able to properly assess the work of students who solve problems in an unconventional way. Handing back assignments in the classroom is also an ordeal in itself. Full solutions were provided on the course Blackboard site for all assignments after the due date.

In terms of teaching, the online assignments allow the instructor to pick specific concepts that they wish to focus on and write questions that will enable students to concentrate on learning that concept in order to complete the assignment. It also seemed that, with the online system's ability to randomly generate numbers, cheating, in the form of copying assignments, is prevented. While cheating is not totally eliminated, a student cannot blindly copy an assignment from a fellow student. They would at least have to figure out which numbers to change in the solution, forcing them to think at least a little bit about the solution. This difference was evident from the postings on the course's discussion board, where students would go for help from their peers. When it came to hand-in assignments, students providing the help would often give the specific equations required to come up with the right answer. With regard to the online assignments, students providing the help would try harder to explain the concept while providing a more generic equation, since they knew everyone would have a different set of numbers. As an instructor, the online system allows you to check the student results by individual question, so it is easy to identify where the students have difficulties. This is useful in trying to improve the learning of the students. Through the online system and the way the results are compiled, the instructor is made aware of which areas need more focus. This benefit is not realized with hand-in assignments, where it is up to the TA to gauge where the students have difficulties and inform the instructor.

As discussed earlier, the most important thing for the instructor to consider is the writing of the questions. A significant amount of time needs to be spent on this aspect in order for the implementation of the online quizzes to be successful. Since there are significant time savings in terms of grading and returning student work, more time can be spent on the design of the assignments themselves. Students did provide many comments that were related to the wording of the questions or the graphics associated with the questions, emphasizing the importance of taking care in design of the questions and answers.

DISCUSSION

The online system always has room for improvement; however, it is a matter of balancing the complexity of the system with the usability for both students and instructors. The feedback from the students is extremely valuable and is taken seriously. All suggestions are being considered for improving the system prior to the next fall semester, when only online assignments (no hand-in) will be used in the first-year mechanics course. Certainly, some redesign of the interface shown in Fig. 1 will be implemented. Students will be allowed to print their assignments next year, allowing them a better format for working out the solution and to have subsequent study aids. Next year students will be reminded following each assignment that the full solutions are available to them. There is also the possibility for improvement in the assessment, particularly the issues of part marks and the difficulty of the questions not reflecting the difficulty of textbook or exam problems.

As for the part marks, the students expressed concern about being penalized for wrong answers that carry through from one question to the next. This could be addressed by either having all questions independent of each other or by having more than one correct answer. As a simple example, if question 1 were 'How many days are there in a week?' and the student answered incorrectly by selecting the answer 5, they would be penalized a second time if question 2 was 'How many days are there in 3 weeks?'. If question 2 were reworded as 'If the number of days in a week is 7, then how many days are there in 3 weeks?' This would make question 2 independent of question 1. In addition, if the system could possibly recognize 2 'right' answers, then if the student realized at least that they should multiply the answer from question 1 by 3, then, for their chosen answer of 5, 15 would be the 'correct' answer for question 2.

With regard to the difficulty of the questions, the assignments were probably a bit on the 'easy' side, and the reasons for this were discussed earlier. The students' comments must also be considered keeping in mind that they are a reflection of student *perception* of what is easy and what is difficult. From an instructor's perspective, the students' perception of how difficult or easy a problem is has a lot to do with whether the problem is encountered in a stressful exam situation or a more relaxed assignment situation. Some students commented on the course evaluations that midterm problems were 'way different' and 'way harder' than anything they had seen in class or on any assignment. In fact, last fall, one of the midterm questions was VERY similar to an assignment question. The picture associated with the problem was only slightly different to one assignment question, yet a number of students showed no evidence of understanding how to solve the problem. As was mentioned earlier, the questions on the online assignments were written in a manner that would lead the student through the solution. Larger problems were broken down into smaller

questions such that each question required the student to complete one step in the solution process. This was thought to be a way to provide part marks but probably contributed to the perception that the online assignments were too easy. As is always the case in this course, some students view the material as too easy while others struggle. In any event, in the coming year more 'difficult' questions will be implemented, possibly drawing from previous exams.

LESSONS LEARNED

One of the main reasons that instructors are apprehensive about adopting online testing technology is the lack of human interface. However, in our case, this apprehension disappears when we highlight the amount of work and time saved by this technology. Moreover, the use of the algorithm in [7] and its ability to deter cheating and encourage learning is also a strong selling point. Instructors and students alike are also very concerned about the stability and access of the system. Our web system is a very stable system and access involves some simple steps. We found that a detailed demonstration of the system in front of students improved acceptability of the system by students. Also, we have implemented a good technical support process by developing an online FAQ (frequently asked questions) list, a technical support telephone number, and a help e-mail address for students. We assure students that their questions will be addressed within the day. In addition to the lessons learned in [1], we think the technology evaluated in this paper will make a strong contribution to teaching and learning in any classroom. It must be noted that, in order to provide the stability and the technical support that is essential to have satisfied users, administration must be willing to commit human and financial resources to the implementation and operation of such a system.

The complete system evaluated in this paper could be transferred to other institutions via an institutional license that ensures intellectual property rights are maintained. Alternatively, it can be run as an ASP (application service provider) through an institutional license. However, before any commitment is made, a 30-day evaluation period is available and users can run a demo quiz at any time. For more details about the new system, please contact the first author, Sebastian Maurice, at smaurice@ucalgary.ca.

CONCLUSION

This study presents results that validate the recommendations in Maurice and Day [1] and allows us to answer the question 'Did these recommendations have the intended effect once implemented?' in the affirmative. The study found that the changes implemented in the new online system got positive feedback from the majority of the students in an undergraduate course. While the positive feedback applies to this sample, we feel that the results can be generalized. Specifically, we feel that the changes we have made to the system would garner favorable feedback from other users because our sample of users is representative of general users who use software.

The study also presents an instructor's view. It is evident from this view that the online system helps to minimize the workload on instructors. Also, the online system allows instructors to determine which question was most difficult to most students. This is important, because it allows instructors to explain the difficult questions first and not waste time with other material in tutorials. The ease of checking students' results helps to address students' concerns quickly and efficiently without referring to paper copies. The overall instructor view is that the online system is a valuable addition to their classroom.

We hope we have raised interest in online testing technology and shown that proper design and implementation can have a positive impact in the classroom, and perhaps the curriculum. We need to use technology carefully in order that we may realize positive returns. We hope we have provided a simple roadmap for others thinking of using a similar technology in their classroom. If used properly, technology can greatly improve teaching and learning while saving time and money on both sides of the classroom—this has been our experience!

REFERENCES

1. S. A. Maurice and R. L. Day, Online testing technology: important lessons learned, *Int. J. of Eng. Education*, **20**(2) (2004), pp. 152–160.
2. K. Dickinson, Distance learning on the internet: Testing students using web forms and the computer gateway interface, *Techtrends*, **42**(2), pp. 43–46.
3. D. Jerry, Web-based assessment: innovating the instructional cycle, *Inventio*, **2**(2) (Fall, 2000) (http://www.doit.gmu.edu/Archives/fall00/jdrake.htm).
4. Gary Klass and Lane Crothers, An experimental evaluation of web based tutorial quizzes. Paper prepared for American Political Science Association annual meeting, (September, 1999) (http://lilt.ilstu.edu/gmklass/articles/APSA99klasscrothersAug8.doc).
5. J. E. Wall, Technology-delivered assessment: Diamonds or rocks? *ERIC/CASS Digest* (2000) (http://www.ericfacility.net/ericdigests/ed446325.html).

6. The Connecticut Distance Learning Consortium From CTDLC's Online Student Evaluation Survey (2001) (http://www.ctdlc.org/Faculty/studentsonlineassessments.html).
7. S. A. Maurice and R. L. Day, A spreadsheet method for promoting learning in a non-supervised testing environment, *International Journal of Engineering Education*, **20**(6) (2004).
8. Sandra Kerka and Michael E. Wonacott, Assessing learners online. From Practitioner File, (2000) (ERIC/ACVE staff) (http://ericacve.org/docs/pfile03.htm).
9. J. Schacter, Does technology improve student learning and achievement? How, when, and under what conditions? *J. of Educational Computing Research*, **20** (1999).
10. I. Harel and S. Papert, Software design as a learning environment, in *Constructionism*, Ablex, Norwood, NJ (1991), pp. 41–84.
11. D. N. Gujarati, *Basic Econometrics*, second edition, McGraw-Hill, Inc. (1998).
12. P. Kennedy, *A Guide to Econometrics*, third edition, MIT Press, (1992).

Sebastian Maurice is a Project Manager at M-Tech Information Technology, Inc., a member of the laboratory for Software Engineering Decision Support at the University of Calgary, and also a member of the Project Management Institute. His general area of research and interest is value-based software engineering. He is the founder and chair of the Software Engineering Consulting Consortium (SECCO) at the University of Calgary, has over ten years of combined professional experience as a researcher, software developer and project manager, and has several publications in international journals; one of these publications has been recognized as landmark work. Sebastian has a Bachelor of Social Science degree in economics from the University of Ottawa (1993), a Bachelor of Science degree in pure mathematics from the University of Calgary (1997), a Master of Science degree in agricultural economics from the University of Alberta (1997), and is completing a Master of Science in software engineering at the University of Calgary.

Shelley Lissel joined the Department of Civil Engineering at the University of Calgary in 2001 after being awarded an NSERC University Faculty Award. She teaches first-year mechanics and structural masonry design and is actively involved with seven international exchange programs in her department. Her research interests are in the general area of structural engineering, focusing on behaviour and design of masonry structures. Her current research focuses on the use of new technologies for structural monitoring and the use of alternative and advanced composite materials in masonry structures. She is in the process of establishing a Dynamic Test Facility for Masonry Structures where she will be conducting research aimed at finding solutions to the life-hazard risk posed by unreinforced or poorly constructed masonry structures during earthquakes. She will also study the use of native materials to produce low-cost earthquake-safe housing for developing regions.

APPENDIX

Survey questionnaire presented to students in electronic form.

On a scale from 1–5, 5 being the best, please comment about the following:

1. **Ease of accessing the online system**
   1 2 3 4 5
2. **Ease of use of the online system**
   1 2 3 4 5
3. **The online assignments helped me learn the course material**
   1 2 3 4 5
4. **The online assignments helped me prepare for the type of examination questions on the midterm.**
   1 2 3 4 5
5. **Please provide comments below specifically about how you think access and ease of use could be improved:**