Online Testing Technology: Important Lessons Learned*

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We report results on how design aspects of technology and perceptions of students towards online testing technology affect the learning and preparation process of students. Using data from a survey of 285 university students, we present their feedback on whether online testing was an effective tool in helping them learn the course material and a good preparation for in-class exams. The lessons we learned may be helpful to others who plan to implement, or develop, similar technology in their classroom. Our results are not surprising, but offer further insight into the learning process of students and how this is affected by technology. The results provide a basis for further study into other areas of online testing such as: cheating by students and how this can undermine learning and understanding of course material; security issues as they relate to test questions; and how perceptions towards technology affect learning. Our results also reinforce the view that technology design, ease of use, functionality and accessibility must be given high priority by administrators and developers because these factors can influence the learning, and preparation, process of students. Ignoring these factors can lead to extremely unhappy students who expect to learn without being inhibited by technology.

INTRODUCTION

THE FACULTY OF ENGINEERING, University of Calgary, has implemented a multiple-choice online testing software that is used to test students in large freshman and junior courses. This software is currently in use by hundreds of students registered in undergraduate courses, and is an official part of their university course requirement. As class sizes continue to increase, the testing application (TA) and the testing process have been helpful in managing and assisting the learning process of students, while minimizing the workload on instructors and teaching assistants, especially when it comes to marking quizzes, tabulating statistics, and helping students understand the course material.

Testing students the *old-fashioned* way, i.e., in-class paper quizzes or tests, requires considerable time and effort on behalf of instructors and teaching assistants, especially in very large classes. The TA has helped to minimize time and effort related to conducting quizzes or tests while providing students with an effective tool to enable them to learn and understand the course material as they prepare for midterms and final exams. The TA system also trains students to cope with evaluation methods that are time-restricted—such as final examinations.

The purpose of this paper is to analyze the effects of online testing technology on the learning and preparation process of students. Very few studies exist that actually survey students in a university setting to find out how they perceive online testing technology. In particular, we look at how an online testing system affects the learning process of students, and whether it is an effective tool to prepare students for in-class exams, such as midterms and the final exams.

ONLINE TESTING AND LEARNING

The objective and purpose of tests is to give students the opportunity to be evaluated on their understanding of course material. In contrast to in-class paper tests, online tests add another dimension to the testing paradigm such as design, usability and access issues that may or may not influence the learning process. Technology that is poorly designed, not user-friendly, and difficult to access can increase stress and anxiety that could detract from a positive learning experience [4, 7].

Much of the literature on the effects of educational technology and technology use on learning remains largely inconclusive [8]. While some studies find that environments enriched with technology lead to students that perform well in other subject areas [8], other studies find that computer use does not have positive effects in every area [11]. Students, however, learn more in less time, and develop a more positive attitude when they receive computer-based instructions [11]. Some studies have found that a positive attitude towards technology and familiarity with the software, and proper teacher training with the software leads to high level of achievement in test scores [12]. Success with technology use does require one to

have a positive attitude towards computers [7–9, 11, 12].

Several studies [8, 9, 11,12] have found that learning technology is ineffective when the learning objectives are unclear and the focus of the technology is diffuse. This would reinforce the need for students and instructors to be properly trained on the technology before it is used for testing.

Online testing process overview

The software testing application (TA) that has been developed is used by students as a client/server application, designed for the Microsoft Windows family of operating systems. In particular, the TA as the following features:

(a) Allows students to do a quiz online anytime, anywhere. The instructor(s) control the start date and end date and can also tell the quiz system to only accept connections from certain Internet IP addresses, and/or students

(b) Marks all answers instantly and emails the results to students after the completion of the quiz

(c) Sends instructors an automatic email, with an Excel attachment, after the end of the quiz. This Excel document contains all grades from students who have taken the quiz

(d) Provides a unique method for instructors to write questions. We have devised a method that allows the instructor to parameterize a question. The advantage here is that an Instructor need only write a few questions, and the TA will randomly change the parameters in this question, hence changing the question, and the answers—all before the question is displayed to the student

(e) Shuffles the choices to a question to prevent students from memorizing a correct 'choice'.

(f) Allows the use of all the formulas in Excel. Therefore, instructors can write their quiz in an Excel document , and the TA will generate the quiz and compute all the formulas before presenting the quiz to the student

(g) Shows instructors the distribution of right/ wrong answers. In a class of approx. 600 students these statistics have been extremely helpful for instructors, during tutorials, to teach and target the harder material quickly and effectively.

(h) Allows instructors to attach graphics (GIF, BMP, JPG) to particular questions and/or choices—opening the avenue for more complex tests requiring diagrams and/or equations.

(i) Allows instructor to choose a subset of questions from a bin of questions, and can send these questions randomly or sequentially to the student.

(j) Operates on a 64-bit encrypted platform. Together with some of the above methods, this has contributed to minimizing cheating in the form of students copy/pasting questions for the use of other students, getting help from a colleague, etc.
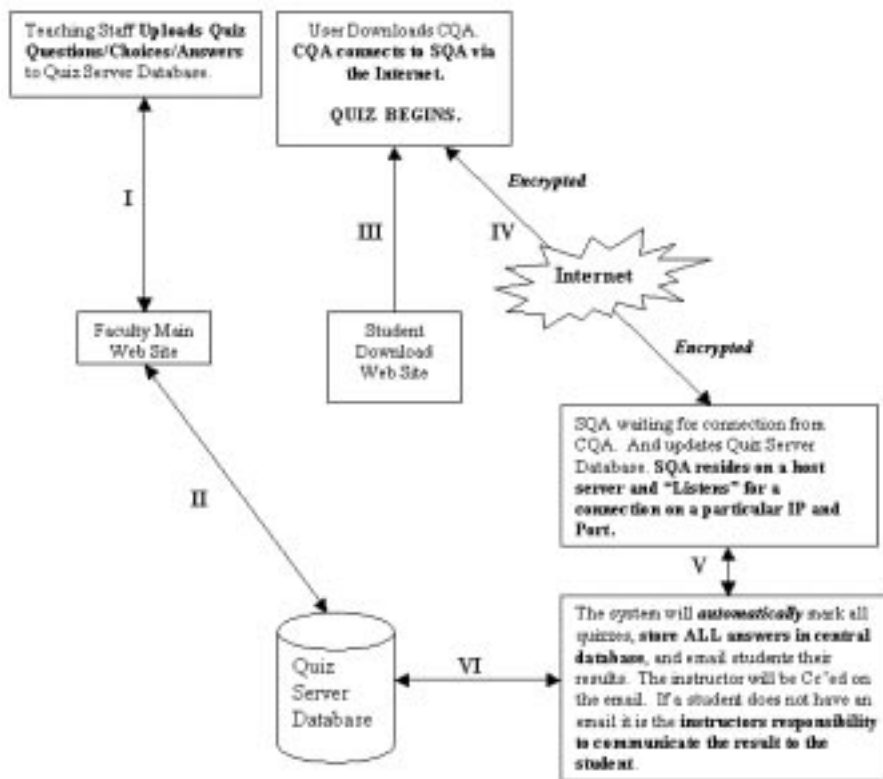
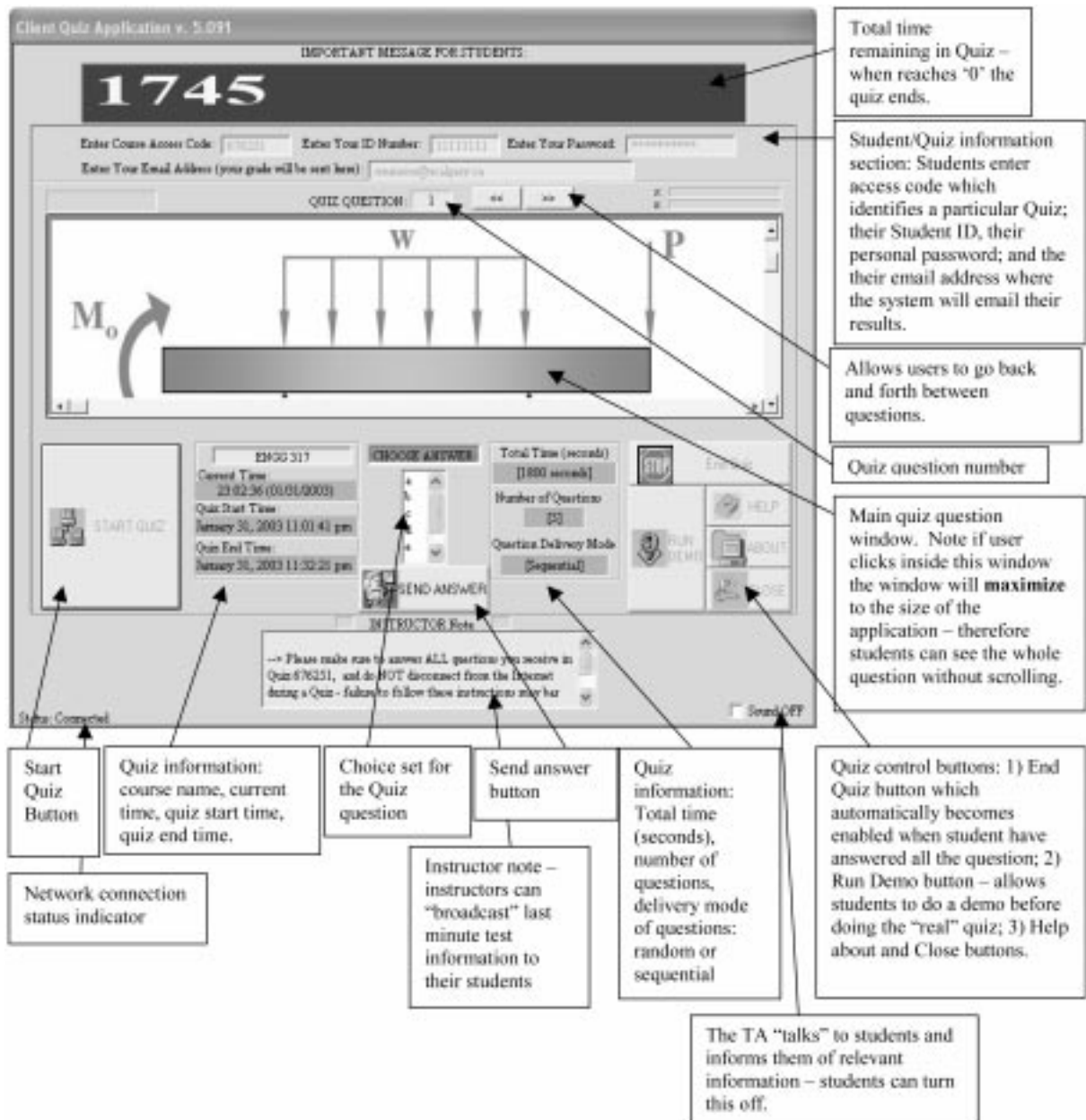

Fig. 1. The online testing process.

Fig. 2. The testing application (TA).

The TA is a client/server application as shown in Fig. 1, and is explained 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 download site to download a client TA software. Students only need to do this once for a particular computer.

Step IV: The TA then connects over the Internet to the server quiz application (SQA)—and the Quiz begins. All communication between the TA and SQA is 64-bit 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 TA presents the student with their grade. The SQA automatically emails the student a detailed explanation of their quiz results such as the questions they answered correctly or incorrectly. Figures 2 and 3 show the TA in its current form.

Survey data

285 engineering students registered in an undergraduate Probability and Statistics course in the Faculty of Engineering were sampled over a two-month period. These students were presented with an electronic survey immediately following their online quiz. This survey is shown in Appendix A. The survey asked students questions relating to access and use of the online system, as well as if this online system helped them learn and prepare
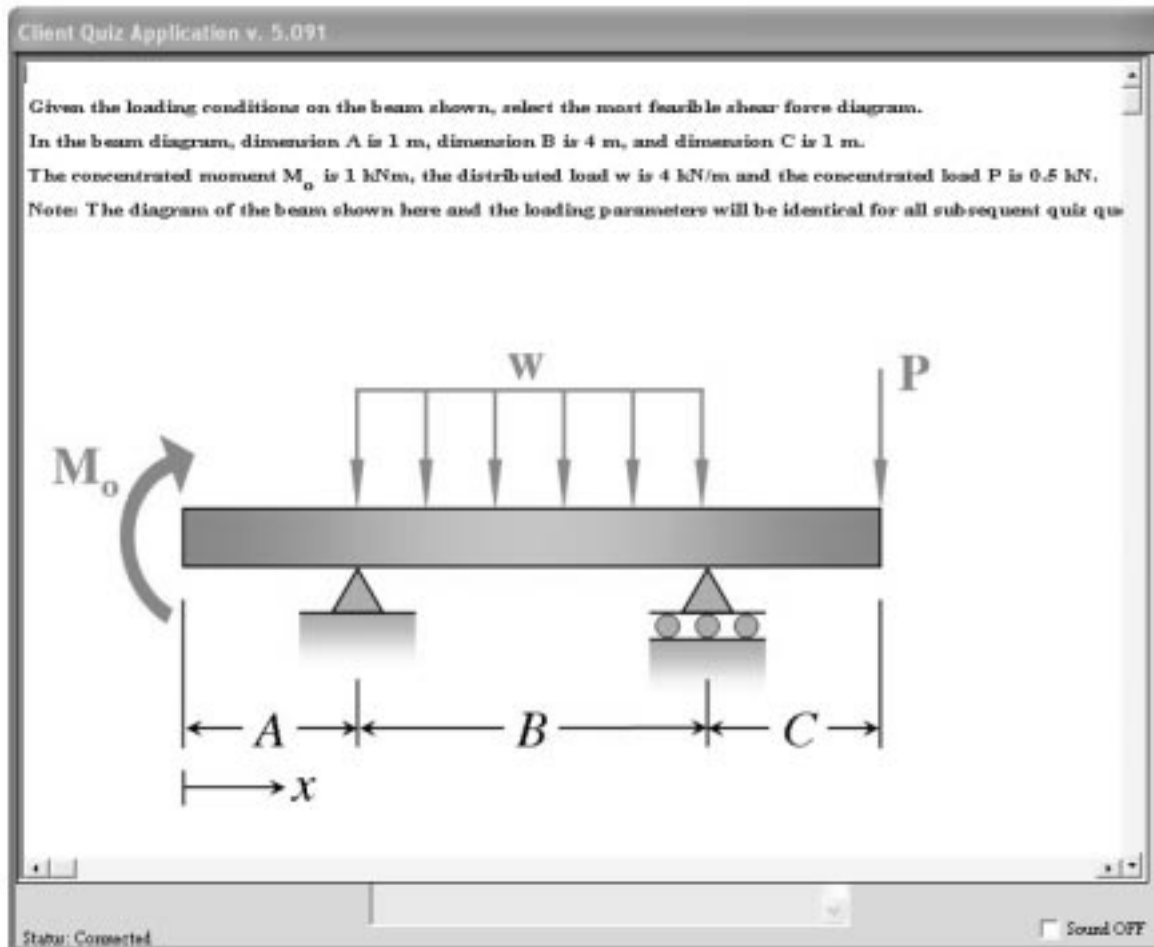
Fig. 3. Same question as shown in Fig. 2 but with a maximized question window.

for the midterm and final exam. Table 1 shows all the survey questions as well as for convenience, a variable associated with the question for easy reference.

Survey results

The results of the survey, shown in Table 1, indicate that students in general viewed the quiz process as *below* satisfactory. Meaning, on a scale of 1–5, 1 being poor and 5 being best, and 2.5 being satisfactory, students were less than satisfied with ease of access and ease of use in the first-half of the session, with average responses of 2.24 and 2.30, respectively. But, they became more familiar with the quizzing process and the interface, they were more than satisfied with the quiz process in the second half of the session, with average responses of 2.59 and 2.63, respectively. Furthermore, students were less than satisfied with the learning and preparation aspects of the quiz system, with average responses of 2.22 and 2.42, respectively. However, many were split on whether online testing was better than in class paper quizzes, which got an average response of 2.54. The confidence interval for the mean shows that we are 95% confident that the mean will lie in this interval. We make the assumption here that our data is

normally distributed [1, 2]. Also note the tightness of the intervals, which is evidence that our mean is close to the true mean of the population data. The variance numbers are presented for completeness and show that the variances are small but larger for the COMPARE variable—which may indicate a lack of consensus, among respondents, for this variable.

Of the 285 students who answered the survey, 139 also answered the OPEN questions. To analyse the results from the OPEN variable we used a survey coding method as follows. The responses for the OPEN questions were scanned for any common themes. Theses common themes were then assigned a code and the responses were then grouped according to these codes. The responses were first grouped in to summary codes: DESIGN, USABLITY, ACCESS, FUNCTIONALITY, INCLASS, LEARNING, OVERALL. The summary codes were then broken down into sub-categories: poor, satisfactory, good.

Table 2 shows that many of the students felt the TA was poorly designed, difficult to use and access, functioned poorly, preferred in class quizzes, not very helpful learning tool, but were almost split, interestingly, on its overall effectiveness. While we were not expecting these results, we

Table 1. Average survey results from 285 students

Question	Variable	Average response	Confidence interval for mean (95%)	Variance
Ease of accessing the quiz system in the first half of the session	EA1	2.24	(2.09, 2.39)	1.54
Ease of accessing the quiz system in the second half of the session	EA2	2.59	(2.44, 2.74)	1.75
Ease of use of the quiz in the first half of the session	EU1	2.30	(2.15, 2.45)	1.67
Ease of use of the quiz in the second half of the session	EU2	2.63	(2.47, 2.79)	1.81
The on-line quiz helped me learn the course material	LEARN	2.22	(2.06, 2.38)	1.76
The on-line quiz helped me prepare for the type of examination questions on the mid-term and final examination.	PREPARE	2.42	(2.27, 2.57)	1.66
How does the on-line 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 email detailing the questions you got wrong/ correct, etc.	COMPARE (The COMPARE variable picks up the students like or dislike towards the technology. If students choose 1, then the system compares poorly to paper quizzes, if they choose 5, it is more superior to in-class tests.)	2.54	(2.37, 2.71)	2.1
Please provide comments below specifically about how you think access and ease of use could be improved:	OPEN	Open-ended		

were quite surprised how strongly some students voiced their displeasure. Table 3 shows some of their responses.

DISCUSSION

While we would have much liked to report more pleasant results, these results have taught us important lessons:

1. Students value technology that is well designed, functions properly and is easy to use and access. If this is not the case, then, as one student so eloquently put it, '. . . get it through your heads that technology is crap and you are ruining my learning experience . . . not only is this test system degrading . . . it ruins self esteem . . .'
2. We were somewhat surprised to find that while students are more willing to accept 'structure' when it comes to in-class tests, they did not prefer this for the online testing tool. Perhaps, since this was an online tool, similar to an Internet, they felt they should be given more freedom.
3. Students felt the system was not reliable or not stable in their computer—system stability was a big issue.
4. Students did not like scrolling in the question window. Scrolling took time, and just caused more frustration.
5. Students did view the TA as an opportunity to learn the course material and prepare for exams. And that the problems with the TA was thought to impede the learning process.
6. Students enjoyed the flexibility offered by TA of doing the quizzes anytime, anywhere. But

Table 2. Cluster analysis of OPEN question

	Design	Usability	Access	Functionality	Inclass	Overall	Learning
Poor	111111111 11 11111111 (20)	1111111 (7)	111111111 1111111111 11 (23)	11111111111111 11111111111111 11111111111111 111111 (48)	11111 (5)	111111111 1 111111 111111 11111 (27)	1111111 1 (8)
Satisfactory	1111 (4)			11 (2)	11 (2)	1 (1)	1 (1)
Good	11 (2)	1	1	11111 (5)	11111111111 11 111111111 (22)	111 1111111 1111111 (17)	1 (1)

Table 3. Representative responses from OPEN question

	Design	Usability	Access	Functionality	Inclass	Overall	Learning
Poor	'One more note, THE BIG FLASHING CLOCK AT THE TOP OF THE QUIZ HAS GOT TO GO . . . a big flashy distracting object at the top of the screen definitely does not help to ease the stress of the situation.' 'Please do something about the hideous blue background.' 'Interface is grumpy . . .'	'Too little time [for each question] should be total time for whole test—so you can do one [question] fast and get extra time for next questions' 'Can't go back to change answers . . .' 'I guess it worked, it needs an automatic updater, selfinstaller . . .'	'Downloading the application is a nuisance . . .'	'This way is harder and more harder and frustrating. When I should be learning the material, I'm getting frustrated with the computer . . . it's not a very good testing method.' 'Program crashed repeatedly . . .' 'I found that I spent a lot more time trying to get the program to work than actually writing the quiz'	'I like the idea, but there should be less to the quiz . . .'	'This is one of those times where technology makes things worse. These online quizzes are annoying and unhelpful. Paper quizzes (remember paper?) are best.' 'The online quiz was frustrating . . .'	'I hope you get it through your heads that technology is crap and you are ruining my learning experience . . . not only is this test system degrading . . . it ruins self esteem . . .' 'The online quiz is hard to learn from . . .'
Satisfactory	'Forget the time limit, since these questions are meant to help us review the material . . .' 'The only thing that needs to be improved is being able to read the questions without having to scroll across.'	'I wish the quiz system was less involved with my computer . . . it naturally scares me when the program has the control to close my desktop items . . .'	'Redownloading the quizzes everytime they need to be done is a pain (but I do realize the necessity in updating.) Otherwise a relatively good system.'	'. . . program would not run at all for the first quiz, didn't try for 2nd quiz, 3rd went well, and 4th went well eventually.' 'The quiz system seems to be getting better, but still, I've spent too much of my own time trouble-shooting a system I could easily do without. This system wastes student time.' 'It is a good idea, but I believe the reliability of the program must be improved before future classes use this type of system.'	'I wish the time carried over from question to question like on a real quiz . . . but the instant results were good.'	'I like it—unfortunately it mucks up my system. Perhaps a less complicated system.'	'Online quizzes were disorganized and did not accurately reflect the extremely hard midterm . . .'
Good	'I liked how you added the timer.'	'[Quizzes] are really good for indicating the level of difficulty for exam questions! I think there should be one quiz every week . . .'	'I had no trouble but have a very new and update computer.'	'The system was organized in a proper manner'	'I find in class quizzes to be more useful to me personally, as it is less stressful. And less chance of computer screw ups.'	'I like this system and enjoy its flexibility . . .' 'I like the flexibility of the online quiz . . .' 'I think the online quizzes are generally a great idea . . .' 'Once you get over the annoyance of doing the quiz on the computer, it's a very good thing'	'It is useful to have practice questions. . .so in that way the online quizzes help . . .'

didn't much care for the start and end dates of the quiz.
7. Students did not like that each question had a time limit, they much preferred a total time for the whole quiz.
8. Students wanted more flexibility in answering and changing their answers to questions.
9. They did not like how the TA interacted with their computer and felt that they were losing control of their computer—and felt frustrated, and 'scared', with the technology.

While the above lessons may be clear to many, our results only reinforce the importance of these lessons. As institutions strive to automate to manage large classes to save cost, we must be careful to think of the needs of students, and then the technology, and then how the two will interact. We failed to do this. We learned that technology has a place in the classroom but only if it meets the needs of students with very few obstacles. This is, we believe, only heightened because of the testing aspect of the technology. Our results also reinforce the findings in the literature and accent one fundamental view 'simplicity, simplicity, simplicity.'

Our results show the needs of our students as they relate to the technology and learning. We have understood these needs and have, we are happy to say, modified and redesigned our TA to reflect these needs—see Fig. 2. As can be seen in Fig. 2, we have fixed many of the problems highlighted by students:

- We lightened the 'blue' background. The original color was a much darker blue.
- The main question window can now be maximized, shown in Fig. 3, by easily clicking in it, and brought back to original size by clicking in it again. The maximized question window is large enough to require minimal to no scrolling. Also, when the window is maximized it covers the system clock, eliminating the system clock 'distraction'.
- We eliminated a question time limit, and implemented a total quiz time limit.
- Students can go back and forth between question by clicking the appropriate buttons, and can change their answers if they wish.
- Students now have the flexibility to end the quiz when they choose by pressing the 'End Quiz' button.
- Students can click the 'Sound off' check box if they choose.
- The quiz system now interacts very little with the user's desktop.
- We have taken another look at the code and made it more stable and reliable in different version of the Windows operating system family.
- We have implemented proper training for instructors and students and always give an in-class presentation/demonstration of the online testing technology—with adequate time for questions and answers.
- We have created a website detailing and listing frequently asked questions (FAQ).
- We have implemented an automatic updater and self-installer. Now the system detects if there is a new version available, if so, automatically updates and installs itself . . . requiring 'no' effort from the student.
- At the end of the quiz we present the students with an e-mail box which allows students to e-mail themselves or their instructors any study notes or questions. This is our way of bringing instructors and students closer together.
- We have installed the quiz system in a dedicated computer lab in the faculty which is always open. Therefore, if students do experience problems on other computers, they can always come to this dedicated lab to do the quiz.

Lastly, we have listened to students and taken their concerns very seriously. Students have appreciated our efforts and instructors, and students, are willing to give this system another chance. Our open feedback process is always on alert to find out how we can improve this system and is in constant contact with students via a dedicated e-mail address, phone, and a feedback form. Even though we have made changes, we are continually listening to students and, if applicable, implementing changes that make the system better and easier to use.

CONCLUSION

This paper highlighted important lessons we learned when it comes to online testing technology. While these lessons may be apparent or even obvious to many, we reinforce these lessons. And suggest that any technology for the classroom must understand the needs of its students then clearly understand how the student will interact with this technology. We failed to do this.

Our results should not be surprising, but should offer further insight into the learning process of students and how this is affected by technology. We also don't want to generalize our results beyond our sample. But would suggest that our results be used as a basis for further study into other areas of online testing. Such as cheating by students and how this can undermine learning and understanding of course material, security issues as they relate to test questions, how perceptions towards technology affect learning, etc.

Technology design, ease of use, functionality and accessibility must be given high priority by administrators and developers because these factors can influence the learning, and preparation, process of students. Ignoring these factors can lead to extremely unhappy students who expect to learn without being inhibited by technology.

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APPENDIX

Survey questionnaire presented to students in electronic form
On a scale from 1 to 5, 5 being the best, please comment about the following:

1. Ease of accessing the quiz system in the first half of the session
   1 2 3 4 5
2. Ease of accessing the quiz system in the second half of the session
   1 2 3 4 5
3. Ease of use of the quiz in the first half of the session
   1 2 3 4 5
4. Ease of use of the quiz in the second half of the session
   1 2 3 4 5
5. The on-line quiz helped me learn the course material
   1 2 3 4 5
6. The on-line quiz helped me prepare for the type of examination questions on the mid-term and final examination.
   1 2 3 4 5
7. 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 email detailing the questions you got wrong/correct, etc.
   1 2 3 4 5
8. Please provide comments below specifically about how you think access and ease of use could be improved.

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