Paper ID #19575

Online Quizzing and Incremental Feedback for Distance and Local Students

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Abstract

At the University of Wisconsin-Platteville, we have been offering our electrical engineering (EE) program to place-bound students throughout the state for nine years. These streaming-video offerings occur in concurrence with our local course offerings. The distance portion of our program continues to grow, with distance students now comprising about 25% of the students enrolled in a given course. This expansion of distance students combined with diminishing state resources has led to some unique instructional challenges.

Several years ago we implemented a series of pilot studies to investigate the effectiveness of auxiliary techniques that supplement the instruction for both the local and distance students who are enrolled in these classes. Based on the results from these pilot studies, a multi-year study was implemented to investigate the use of online quizzing and incremental feedback to promote student self-directed learning and improve student confidence. This approach is not a replacement for, but instead a supplement to traditional assignments and projects.

This paper describes the results of that multi-year study implemented in different types of electrical engineering courses. The purpose of the project and student outcomes are summarized. The implementation differences and limitations for the different types of electrical engineering courses (theoretical, mathematical, laboratory) are discussed. The results of student survey data clearly show that students like online quizzing with feedback as implemented in this study. Finally, the implications of faculty workload, both in the short and long term, are discussed.

Background

Since the 2008 recession, in an effort to balance their budgets, many states have greatly reduced their support of their public universities[1]. In addition, some of those same states have limited growth in tuition, in an effort to keep college more accessible. These budget constraints have resulted in reduction of staff, larger classes, and restrictions on course offerings at many universities.

Unlike many other programs at our institution, the enrollment for our undergraduate electrical engineering (EE) program at the University of Wisconsin-Platteville has been increasing, a trend that is expected to continue. This can partially attributed to growth in the number of students in our statewide distance education program. This established program, which has been in place for

nine years, provides place-bound students and working adults the ability to obtain a Bachelor of Science in Electrical Engineering (BSEE) degree remotely.[2,3,4] Local and Distance student sections are taught concurrently by the same instructor. The instructor provides lectures to local students and records them, allowing anytime access by all students. In addition, distance students are permitted to log in and to attend the streaming lecture live if their schedule allows. A traveling lab manager facilitates the offering of lower-level labs at specified sites around the state for distance students and makes sure that the lab equipment is accessible for students taking upper-level courses. In Fall 2016, we had 73 different EE distance students taking classes out of a total of 477 EE majors total, a number which includes intended majors taking EE classes.

Due to budget constraints, our university over the last several years has decided to increase faculty workload through the combination of leaving open positions unfilled and increasing the average class size by either consolidating multiple sections or by offering classes less often. At the same time, there has been a reduction in the number of support staff. This combination has altered the classroom environment for faculty, requiring them to alter their teaching methods to accommodate a larger number of students, both local and distance.

The number of distance students in class offerings has been steadily growing. In Fall 2016, we averaged 16.67 distance students in the required EE classes that we offered, making up about a third of the total class for those instructors. It is common to have 20% or more distance students enrolled in popular technical-elective classes as well. These numbers suggest that we may need to increase the streaming offerings of core lower-level electrical-engineering courses from every other semester to every semester in the future.

Faculty responded in different ways to this increase in faculty workload. Some reduced the number of graded items across the entire course (homeworks, exams, reports, projects, etc.). Others eliminated all graded homework because 1) it is time consuming to grade homework and 2) some students rely on other students or online resources for their answers. A few faculty did not change their approach and either hired graders to cut down on their added workload or moved on (went to industry or retired).

In anticipation of increasing enrollments and higher university workload demand, we completed a series of 3 pilot studies[4] in the 2013 -2014 academic year to evaluate methods to improve student learning for both local and distance students that would be sustainable in terms of faculty workload. One of those methods involving the potential use of online quizzing as a partial replacement for homework was studied in more depth. The results from a multi-year study, including data from different types of electrical engineering courses, are described in this paper.

Traditional Quizzing vs Online Quizzing with Incremental Feedback

With the growth of the distance EE program and the increased workload levels on main campus, it is clear that our current instructional model for distance students is not sustainable long term. Small numbers of distance students in a larger local section have been accommodated using individual office hours and small-group discussions. Now that the typical class with distance students has over a dozen distance students, new approaches need to be developed to make faculty-student interactions more efficient.

One approach that has been traditionally used to reduce the amount of grading is to assign weekly, ungraded homework and then give weekly graded quizzes[5-7]. This approach forces students to complete enough homework to pass the quizzes. While this may be a viable option for local course offerings, the process becomes much more complicated when distance students are involved due to the additional time needed to arrange proctors, quiz times, and different versions of the quiz. While online versions for testing could be used[8-10], you need a method to verify a student is not cheating.

A much better alternative for courses with distance students, which is denoted as Online Quizzing with Incremental Feedback in this paper, removes the motivation for students to cheat to avoid a bad grade and replaces it with one focused on learning. In the Online Quizzing with Feedback approach, you enter in the quiz as 5 separate quizzes instead of a single 5 question quiz. When a student answers the first quiz problem and answers it incorrectly, they get specific feedback as to what they did incorrectly but are not given the correct answer. The student then must retake that quiz problem as many times as necessary until they get it correct before they are allowed to move on to the next quiz question. If they complete all the assigned quiz questions correctly prior to the deadline, they get full credit for the online quiz. The relative advantages of this technique are that it provides immediate feedback to the student (unlike traditional homework in large classes, where graded feedback may take up to two weeks) and since the students get full credit if they correctly take each problem to completion, there is little incentive to cheat. To minimize this incentive further, the quiz is incorporated into our learning management system where the instructor can track student responses and can quickly determine if a student is trying to game the system. In turn, the instructor announces to students that he has that capability.

In our 2014 pilot study[4], these online quizzes with feedback were used as pre-homework assignments (20% of the homework grade), where basic misconceptions could be corrected or large problems could be broken down into incremental pieces to guide students through a problem before assigning a follow-up traditional homework assignment (80% of the homework grade). The pilot study showed that this approach provided potential for improved student learning and that students liked the immediate feedback provided by the online homework.

Multi-year Study Incorporating Online Quizzing with Incremental Feedback

To better assess the best use of online quizzing with incremental feedback, a multi-year study was developed to answer the scholarship of teaching and learning (SOTL) questions listed in Table 1. In an attempt to answer the first half of SOTL question 1, the percentage of online quizzes with feedback to total homework (online feedback homework + traditional homework) were varied during three different offerings of the same class, Solid-State Electronics. This elective class was selected because it was one of the courses used in the initial pilot study, the course was being offered regularly, and a single instructor taught this course. As shown in Table 2, if online quizzes with incremental feedback are almost exclusively used (94.4%) or if online quizzes are seldom used (20%), the percentage of students receiving grades of D or F (D/F) rose from the single digits to the mid to upper teens. It stresses the point that the learning of certain threshold concepts is better achieved through the completion of traditional homework instead of through online quizzes. Here multiple-choice online quizzes were used due to restrictions with the current learning management system. The number of distance students are listed under the streaming video (SV) column. It should be noted that only one of the D/F grades in Spring 2015 was received by a SV student and the distance students with poor performance (16.67% D/F grades) mirrored that for main campus (18.18% D/F grades).

Table. 1. SOTL Questions for Multi-Year Study Incorporating Online Quizzing with Incremental Feedback
1. What ratio of Online Quizzing to Traditional Homework is Optimal? Does it depend upon the class offering?
2. Does online quizzing with feedback contribute to improved student learning?
3. What Online Quizzing implementation parameters are important to EE students?
4. Does Online Quizzing with Feedback provide a significant reduction in faculty workload?

Table. 2. Comparison of student learning in Solid-State Electronics vs Ratio Online Quizzing with Incremental Feedback Homework to Total Homework

Semester (# students)	Ratio online quiz homeworks to the total homeworks	Percent receiving D or F	Distance students in the class
Spring 2014 (7)	20%	14.29%	6
Fall 2014 (14)	60%	7.14%	0
Spring 2015 (17)	94.4%	17.65%	6
Fall 2015 (20)	81.8%	5.00%	0

In an attempt to answer the second half of the first SOTL question, Electromagnetic Fields was selected because it was a core EE course, it was one of the courses used in the initial pilot study, and because it was very different than Solid-State Electronics in terms of its math content. Although both courses are highly theoretical, Electromagnetic Fields is highly dependent on Multi-Variable Calculus whereas Solid State Electronics requires mostly simple math. Again it

was shown that the percentage of D/F grades decreased when online quizzes with incremental feedback homework was alternated with traditional homework. In Spring 2016, the online quizzes with incremental feedback homework was used to help students to better understand key concepts and guide them through the solution of multi-step problems prior to giving them a more complicated traditional homework set. It should be noted that the Spring 2014 Electromagnetics Fields course was offered back to main campus from a remote site.

In Fall 2016 online quizzing with feedback was introduced into two new courses, Analog Electronics and Engineering Computation. In Analog Electronics, online quizzes with incremental feedback homework was alternated with traditional homework for the theory portion of the course only. Since Analog Electronics is so lab intensive, it might be beneficial that future offerings include online quizzes with incremental feedback homework for the lab portion of the class as well.

Engineering Computation is a course that includes linear algebra, probability and statistics, Matlab, Simulink, and electrical engineering applications. Unlike many of the other offering where online quizzes with incremental feedback homework was alternated with traditional homework throughout the course, in this class traditional homework was used exclusively for linear algebra homework, while online quizzes with incremental feedback homework was used exclusively for probability and statistics homework. This course did not have any D's or F's. The last two previous course offerings, which used traditional homework exclusively, had 16.67% D's or F's and 0% D's or F's respectively.

Table. 3. Comparison of student learning in other EE courses vs Ratio Online Quizzing with Incremental Feedback Homework to Total Homework

Semester (# students)	Ratio online quiz homeworks to the total homeworks	Percent receiving D or F	Distance students in the class
Spring 2014 EM Fields (33)	20%	18.18%	28
Spring 2016 EM Fields (50)	50%	10%	14
Fall 2016 Analog Elect. (48)	57.1%	14.6%	16
Fall 2015 Engr. Comp. (29)	50%	0%	10

Student Feedback

In order to attempt to answer SOTL question 3 in Table 1, students were polled at the end of the semester of several of the course offerings to determine which online quiz implementation parameters were important to them. The first set of four questions that were asked were identical to those asked of students in the 2014 Pilot Study[4]. Table 4 includes both the results from the 2014 Pilot Study and the results from the survey given to three different classes in 2016 where online quizzes with incremental feedback homework was also incorporated. The submission rate for these surveys was on average 47.9%, which is higher than normal for a survey. These results are fairly consistent with over 90% strongly agreeing or agreeing that online quizzes with

individual selection feedback and unlimited attempts were helpful in this course and should be used in future distance engineering courses. Over 75% disagreed with the statements that the online quizzes would have been just as helpful without the individual selection feedback and that the online quizzes should have been graded (like traditional quizzes). This demonstrates that there is a true desire by most students for feedback not so that can have the "right answer" but so they can learn from their mistakes. In the three surveys given in 2016, an additional question non-Likert question was asked about the balance of online homework to traditional homework (see Table 5). While the majority of students believe that the roughly 50% online homework with feedback and 50% traditional homework was about right, less than 12% desire more traditional homework than online homework.

Table 4. Online Quizzes Likert Scale Survey Question Results

(AS) Agree Strongly
(A) Agree
(N) Neither Agree or Disagree
(D) Disagree
(DS) Disagree Strongly

Spring 2014 Solid-State Electronics (survey submission rate: 6/7: 85.71%)
Spring 2014 EM Fields (survey submission rate: 14/33: 42.42%)
Spring 2016 EM Fields (survey submission rate: 22/50: 44.0%)
Fall 2016 Analog Electronics (survey submission rate: 20/48: 41.67%)
Fall 2016 Engineering Computation (survey submission rate: 18/29: 62.07%)

Statement	(AS)	(A)	(N)	(D)	(DS)
The ungraded online quizzes with individual selection feedback and unlimited attempts were helpful in this course.	33.33% 71.43% 72.73% 65% 66.67%	50.00% 21.43% 27.27% 35% 27.78%	16.67% 0% 0% 0% 5.56%	0% 7.14% 0% 0% 0%	0% 0% 0% 0% 0%
The ungraded online quizzes with individual selection feedback and unlimited attempts should be incorporated in future distance engineering courses.	33.33% 71.43% 63.64% 65% 61.11%	66.67% 21.43% 36.36% 35% 27.78%	0% 0% 0% 0% 5.56%	0% 7.14% 0% 0% 5.56%	0% 0% 0% 0% 0%
The ungraded online quizzes this semester would have been just as helpful without the individual selection feedback (keeping unlimited attempts and immediate right or wrong feedback)	0% 0% 4.55% 0% 5.56%	0% 0% 9.09% 10% 22.22%	0% 14.29% 27.27% 15% 16.67%	100% 42.86% 45.45% 55% 38.89%	0% 42.86% 13.64% 20% 16.67%
The online quizzes should have been graded (1 attempt).	0% 0% 0% 0% 0%	16.67% 0% 0% 0% 5.56%	33.33% 21.43% 4.55% 10.00% 11.11%	33.33% 42.86% 36.36% 30.00% 44.44%	16.67% 35.71% 59.09% 60.00% 38.89%

Student were also given the opportunity to provide comments about or suggested improvements to online quizzes. Comments were organized into common themes and a running count of those comments was taken. These common themes are provided in Table 6 together with a representative student quote and the number of similar comments that students made. The most common topic was that online quizzing with feedback was helpful and should be continued. The next most common topic was that online quizzing with feedback should be alternated with traditional homework assignments. This is consistent with the initial pilot student intent of using online quizzes to insure that students have a good understanding of key concepts and methodology to prepare students for the more difficult homework assignments to follow.

Table 5. Online Quizzes vs Traditional Homework Balance Results **Spring 2016 EM Fields (survey submission rate: 22/50: 44.0%)** **Fall 2016 Analog Electronics (survey submission rate: 20/48: 41.67%)** **Fall 2016 Engineering Computation (survey submission rate: 18/29: 62.07%)**	
The balance between the number of online homework quizzes to traditional homework assignments was about right	59.09% 65.00% 66.67%
We should have fewer online homework quizzes & expand the number of traditional homework assignments.	0% 10.00% 11.11%
We should have more online homework quizzes & decrease the number of traditional homework assignments.	18.18% 10.00% 11.11%
We should have more online homework quizzes & keep the number of traditional homework assignments the same.	22.73% 15.00% 11.11%

The third most common topic was that the feedback section of the quizzes should be more detailed, and perhaps after successful completion of the problem a complete, written-out solution could be downloaded. The fourth most common topic was to expand the use of this technique in the current and other courses. The fifth and sixth most common comment was dealing with the limitations of using multiple choice quizzing. Currently we are using the same quiz for follow-up attempts because our current learning management system can only handle randomized quizzing for very simple cases. The seventh most common comment topic involved the timing and frequency of online quizzes. Overall, these comments were quite positive and will be helpful in the planning of future implementations of online quizzing.

Conclusions

Before trying to address the fourth SOTL question in Table 1, which deals with faculty workload, approximate answers are needed to the first three SOTL questions. Based on the data from this multi-year study, the optimal ratio of Online Quizzing with Feedback to Traditional

Homework appears to be dependent on the type of EE course. The ratio was found to be roughly 50/50 for EE courses containing substantial math content. For highly theoretical courses with lower math content, such as Solid State Electronics, more Online Quizzing with Feedback can be successfully used. For heavy lab classes, the role of online quizzing for the lab portion of the class is yet to be determined. While it is unclear if Online Quizzing with immediate feedback is improving student learning in all students, these initial results seem to indicate improved performance of marginal students as seen by the reduced percentage of D/F grades. The results from the survey data in Tables 5 and 6 seem to agree that the use of online quizzing with immediate feedback is very helpful. These results also agree that online quizzing is not a replacement for traditional homework, however, it can be used to greatly reduce the number of graded assignments.

Table 6. Examples of Student Comments Organized by Theme (2016 Surveys)
Theme #1: Immediate Feedback/Helpful **Representative Comment:** "The immediate feedback portion and opportunity to have infinite attempts really takes the stress off of trying to decipher question after question without knowing if you are doing each process correctly or not. The immediate feedback is especially very helpful for learning. I feel as though processes and problem solving is much easier studied and retained when you have a positive response immediately and not days later, after you get a traditional homework grade back. Very helpful method in general." **# of similar comments:** 11
Theme #2: Alternate Between Online Quizzing and Traditional Homework **Representative Comment: "**I like the online homework/quizzes from an understanding of key concepts perspective and like the feedback if you get a wrong answer. I like the traditional homework as well for a deeper understanding. The one suggestion I have is that final answers are given with traditional homework. Not a walk through to the solution but just the final answer this allows you to work through the problem and struggle but ends with the satisfaction of knowing your answer is correct. Sometimes I believe more learning is done if you develop the process on your own but then at the end know that your process is correct. I understand you do this later when homework solutions are given but that is usually weeks later when your mind is focusing on new tasks." **# of similar comments: 7**
Theme #3: More Detailed Feedback **Representative Comment: "**I would prefer more questions, with much more feedback if the answer is wrong. And after the deadline for questions is done, a complete walkthrough of each problem would be very beneficial." **# of similar comments:** 6
Theme #4: More Online Quizzes/Expand Usage **Representative Comment: "**I understand the online homework is a lot of work, but being able to work through a problem and get feedback on where you made your mistake was helpful. Please continue to use these and use them more if possible." **# of similar comments:** 4

Theme #5: Limit Multiple Choice Questions to 2 Attempts **Representative Comment: "**I feel it should be limited to 2 attempts, because with the feedback you should be able to get it second time around and this way it would stop people from just guessing. Otherwise the online homework/quizzes i feel were very helpful in the course." **# of similar comments:** 4
Theme #6: Drawbacks/Limitations of Multiple Choice Questions **Representative Comment: "**The questions in the online quizzes seemed to be a much better preparation for exams then the traditional homework. That may be because they are prepared in the same way. The real draw back to the online quizzes is the multiple choice answers. There were a couple of times when the answers could be narrowed down to one or two possible without actually doing the calculations. Of course, narrowing the possible answers down requires an understanding of the material its self, so maybe that isn't such a bad thing..." **# of similar comments:** 3
Theme #7: Timing of Online Quizzes **Representative Comment: "**You could teach a few items and then have problems that are supposed to help with understanding the material due within a day or two. This allows for immediate feedback on topics and will help get students thinking about what is being taught instead of waiting until the homework is due." **# of similar comments:** 3

Based on the answers to the first three SOTL questions, it appears that the use of online quizzes with immediate feedback will not produce any reduction in faculty workload in the short term. This is because the time needed to develop the initial set of online quizzes with incorrect answers and immediate feedback has been found to be roughly equal to the time required to grade traditional homeworks. Therefore, the faculty member is not likely to see any substantial workload benefit until a complete database of online quizzes have been developed. The one exception to this would be the development of lab related quizzes. Helping students at a distance to troubleshoot their design projects is a major time sink for faculty. Giving students instructions/videos for making lab measurements on a test set-up and helping them through the use of online quizzing to eliminate equipment set-up/measurement issues prior to completing the lab could greatly reduce the lab-related portion of a faculty member's workload.

Of course, the overall development time will depend upon several factors including the software and support staff available at your institution for creating and maintaining a series of online quizzes with feedback. We are currently working with our Teaching and Technology Center to greatly reduce the faculty time required for quiz development, to create multi-level quizzing functionality, and to develop more personalized feedback options.

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