Three pilot studies with a focus on asynchronous distance education

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Abstract

For the last five years we have been offering our electrical engineering (EE) program to students throughout the state using streaming video lectures and local lab offerings facilitated by traveling lab managers. Much of that time has been spent improving different aspects of our courses such as online office hours, web-based content, distance lab offerings, and online assessment of student work. Although the asynchronous lecture approach provides increased access for working students who are completing the program on a part-time basis, it poses a number of instructional challenges.

This paper discusses several ongoing pilot studies which investigate the effectiveness of auxiliary techniques that supplement the instruction for both the local and distance students who are enrolled in these classes. These studies use technology to expand the resources available to the student. One study uses mini-videos and quizzes to address review material, reading assignments, and lab equipment training. Another looks at the use of flipping the classroom to make room for in-class problem solving. A third project uses pre-homework assignments and online quizzing with incremental feedback to promote student self-directed learning and improve student confidence. Student survey data, relative student performance, and faculty workload will all be discussed.

Background

In the fall of 2008 the Department of Electrical Engineering at the University of Wisconsin-Platteville began a collaborative distance education program where place-bound students could complete their entire four-year electrical engineering (EE) degree from any of the university system’s two-year college sites located throughout the state. Once students have successfully completed their core pre-engineering courses they apply for electrical engineering major status at our university. After matriculating into the EE program, they concurrently take courses to satisfy their Associate’s Degree program at their local two-year school and their Bachelor’s Degree program in electrical engineering.

Since the inception of the statewide collaborative program we have been continually adapting the program to meet the needs of distance students. Initially we tried to adapt our traditional core EE courses for a non-traditional distance student audience. Distance labs were facilitated by traveling lab managers. The managers can travel to up to 13 different sites throughout the state and typically assist with labs for 5 to 7 courses each. Some of the courses required more lab work than others. On average the lab managers were travelling three days per week and on each
trip they could cover anywhere from 100 to 500 miles. For entry-level courses, such as Circuit Modeling I, traveling support staff can be used to assess proper usage of lab equipment and to evaluate the construction and performance of simple circuits. Since they cover locations throughout the state, the two lab managers usually create a biweekly site schedule which both students and faculty can plan around. They work with engineering faculty to ensure that the remote students have a lab experience equivalent to those on main campus. For upper-level courses, the lab managers distribute the appropriate lab equipment to the remote sites at the start of the semester. Remote student laboratory check-offs are typically handled by faculty and student alone via webcams and web conferencing software during scheduled office hours.

Next we sought to improve office hours for distance courses through the use of web conferencing software and pen-tablet technology which allowed students and faculty to write on the same electronic piece of paper. With the growth of the program, we expanded our use of technology to allow real-time troubleshooting of lab equipment/work and the assessment of higher-level design projects at a distance.

After spending the last several years about improving distance course logistics (distance design labs, office hours, and assessment), we wanted to concentrate on supplemental instructional methods that would meet the needs of our distance educational program. Lectures for this program have been asynchronous (via streaming video (SV)), by design. This was done to provide maximum access for place-bound students with widely varying scheduling needs to obtain a B.S.E.E. degree in collaboration with their nearest two-year university system school. The use of SV content in distance offerings continues to provide a series of challenges for our EE faculty, who must simultaneously meet the needs of both our local and our distance students. In order to better overcome these challenges, we have identified several promising supplemental instructional techniques which were evaluated in three pilot studies that took place in fall 2013.

The first pilot study evaluated the use of short instructional videos and recorded lectures in distance course offerings. The second pilot study focused on a flipped classroom experience where a significant number of the students were taking the class asynchronously. The third pilot study investigated the use of pre-homework assignments and online quizzing with incremental feedback to promote student self-directed learning and improve student confidence. Each of these studies looked at student perceptions (survey data), student performance, and implications that usage would have on faculty workload.

**Pilot Study 1: Short videos and recorded Lectures**

In an attempt to improve the educational experience and student learning for both distance and local students we have been employing various technological tools. Though the use of these tools was initially instituted to aid distance students, local students have benefited from the use of them. Two of the tools used have been short instructional videos (approximately 10 minutes each) and web conferencing software (Blackboard Collaborate) to record classroom lectures.
The web conferencing software records a tablet computer screen on which course material is presented, along with the voice of anyone participating in the online conference room. The audio interface for the instructor is a Bluetooth headset, so students in the classroom only hear the instructor.

The instructional videos have consisted of CAD demonstrations. These videos have walked students through basic examples of circuit layout and simulation. These demonstrations were previously done during classroom time. Through the viewing of these videos, students have been able to acquaint themselves with the computer tools necessary for the course and review material as needed throughout the semester. Student proficiency in the use of the tools has not suffered. Additionally, the amount of instructor time required for the support of these tools has dropped to minimal involvement.

Students are encouraged to watch the videos initially by giving an online quiz regarding the video content. Later in the course, however, assignments that use the tools presented are given instead of the quizzes. Once students have been introduced to the videos, very little encouragement is necessary to get them to use them. Students have requested that these types of demonstration videos be made not only for computer programs, but also for laboratory equipment.

Students were surveyed in three courses, freshman and sophomore level circuit analysis and junior level electronic devices, regarding their perceptions of the effectiveness of these videos. All three courses had a 66% response rate from students enrolled during the last week of the courses. It should be noted that the content of these videos demonstrated a SPICE tool, so they were more pertinent to the lower level courses, as indicated by the results of the surveys.

Figure 1. Survey results of three courses regarding the use of demonstration videos indicating use in lower level courses.
Figure 2. Survey results of three courses indicating the usefulness of the demonstration videos in lower level courses.

Figure 3. Survey results of three courses showing overwhelming support for the creation of more demonstration videos.
It is interesting to note that even in the course where the published videos did not pertain to the course material, the students supported the concept of the videos and desired for more to be created.

Lectures and discussions recorded using web conferencing software have been helpful for both the students and the instructor. Both lecture notes and explanations are recorded. The on demand availability of lecture material allows students to review recorded material whenever needed. Since students are able to review lecture material when they need it, which is often in the evening when they are studying, students learn to answer many of their own questions. This increases their self-directed learning, while reducing the number of trips the students make to the instructors office hours.

The use of web conferencing software to record lectures has resulted in some unforeseen benefits. Initially, web conferencing software was used as a portable method of recording lectures. Using the web conferencing software made it possible to record any class in any room that had the ability to project a computer screen. However, since web conferencing software was used, some distance students started attending lecture synchronously (our program is designed for asynchronous delivery). This allowed distance students to participate in classroom discussions, as their schedule permitted. Not only could distance students participate in class in this manner, but local students travelling for such things as job interviews were able to participate in class.

As part of the same survey given to the students, they were asked about the recorded lectures and electronic lecture material. These lectures were presented in two different styles, with the introductory circuits courses being taught in a discussion style interactive manner, while the electronic devices course was taught in a more disseminating, linear presentation style. We believe that this accounts for the stronger usage in the electronic devices course of the recorded lectures.

In all three courses the students used and appreciated the availability of an electronic copy of the notes from the course. These were a record of the actual contents of the board presented in class. One distinct advantage of the recorded notes was that student questions, during office hour contact, regarding lecture material were directed; with students often bringing a tablet device with the electronic notes to the office to ask for clarification on a particular point.

Overall students seem to prefer having on demand electronic resources available to them. As we endeavor to create higher quality more targeted resources, we expect this preference to increase. There is a heavy front end investment of time in the creation of these resources; however, by making on demand resources available to students, the amount of time spent supporting students during the course (i.e. office hours) is reduced. As long as student performance remains constant or improves with the use of these resources, they are valuable in reducing the overall workload of the instructor.
Figure 4. Survey of the three courses of student use of the recorded lectures indicating much higher use in the electronic devices course.

Figure 5. Survey results showing how the students felt about the recorded lectures again indicating a preference for the presentation style recordings.
Figure 6. Survey results showing usage of posted lecture notes.

Figure 7. Student evaluation of the usefulness of the posted lecture notes indicating that most students found them helpful.
A future project that will be undertaken is the creation of short instructional videos covering course material. These videos are intended to replace traditional lecture presentation of material so that class time can be used to go over examples and for students to practice problem solving. When presented with this prospect, students in all three courses have almost no objection to the concept.

![Chart]

**Figure 8.** Student surveys regarding course material being presented in short video format.

These videos will first be used in an introductory circuit modeling course. After the introduction of the use of these videos is coupled with a flipped classroom model, an analysis of student performance compared to historical performance in the course will be done.

**Pilot Study 2: Flipped Classroom with Local and Distance Students**

Students often complain that faculty don't spend enough time doing examples in class. Faculty complain that students don't spend enough time out of class studying the required material. The students say the book is boring and they can’t learn from it. There never seems to be enough time to cover all the material and get to a sufficient number of examples in lecture. Students seek allot of feedback while they work on homework, but too much feedback leads to tutoring and “handholding”. Flipping the classroom is one way to get more time to do examples, give timely feedback to students without undue faculty time commitment, and to get the students to spend some time outside of the classroom preparing for class. During fall 2012 our signals and systems class was offered to our distance students via streaming technology and the lectures were recorded live in front of the face-to-face section at the Platteville campus. In fall 2013 the course was taught again and the students were required to watch the lectures from the previous year.
The course followed a simple structure. At the beginning of each section of the course we assigned a reading selection from a textbook, a viewing selection from the previous year’s recorded lectures, recommendations for a web site or two, some practice problems from the book, some practice problems with varying degrees of solutions supplied from full solutions to answers only, some problems that would eventually be done in class, sometimes from the book and sometimes from other sources, and finally homework problems were assigned for collection and grading. At the end of each section or so, exams were held. Class time was used for examples and student centered problem solving, and some small amount of lecturing. The whole course is interspersed with lab work.

The text reading assignments included a short synopsis highlighted with notes about especially important concepts, equations, examples or tricky steps in typical designs or analyses, and connections to fields of interest to our students. The recorded lectures were supplemented with a set of advance release skeleton notes with 30% - 70% on each page left open for the student to fill in and by a set of post release notes that were filled in while lecturing. The supplemental videos from the web were mostly real-world demos of important concepts from the class (try searching Youtube for “aliasing propellers” to get the idea). Visits to Wikipedia or similar pages challenged the students’ notions of notation and convention, and exposed them to connections to a wide variety of STEM disciplines. The practice problems were chosen to give the students exercise with the jargon, notation and variables, equations, and concepts. None of the practice problems were more than one or two simple steps or application of some obvious technique. In-class problems were selected so that the students would get to go through problems with more difficult concepts or with multiple steps, and typically there was an in-class problem that corresponded to each graded homework problem, more or less. The distance students were less involved in the in-class problems because of the logistics. The instructor met with the students in an online room a minimum of twice per week to discuss the in-class problems and other topics of interest to the students. The homework was assigned from the text or made up by the instructor to illustrate the main engineering concepts that weren’t illustrated in the labs.

Student Survey Data

The regularly scheduled lecture and discussion time from the current semester were also recorded and made available for the students to view as streaming video. The scheduled lecture time was informally divided into mini-lectures (15%), in-class examples (50%), and in-class homework (35%). The local students were encouraged to ask questions during the mini-lectures and the in-class examples, but students were encouraged to answer each other’s questions as much as possible during the in-class homework sessions.

In addition to the usual office hours for the face-to-face students, an afternoon and an evening distance-student office hour/discussion/lab check-off period was provided that ran through an online conference room. The majority of our distance students are non-traditional students with
significant time restrictions (that’s why they are in our asynchronous program) and it soon became evident that they would not all be able to make the scheduled hours two more hours were scheduled in the evenings and the afternoon session was cancelled. These sessions were recorded whenever they were used as discussions or by permission of the student when they were office hours, but they were not recorded when they were used for lab check-offs. All these recordings were available for all the students to view.

A single anonymous survey about various aspects of the course was posted on the class webpage at the conclusion of the semester. The local and distance students took the same survey and are not separated in the results. Twenty-three of the fifty students responded. Many of the questions had answers varying by degree on a Likert scale, a few were comments, and one was a binary answer. The first group is summarized in Table 1.

The first three questions in Table 1 are related to the way the in-class time was organized. The majority of students felt that the way the lectures, discussions, and homework assignments were handled helped them learn the material. The next three questions were not really specifically related to the object of the pilot study so we will not discuss them further except to say that we will try to get more students to use our on-line office hours in the future.

When the students were asked in the comment sections of the survey what aspects of the current lecture format they liked better than the traditional unrecorded-whiteboard format the students stated by an overwhelming majority (a whopping 73%) that the number one advantage of making recorded lectures available was that they could go back and watch the lecture material whenever they wanted to. The students felt it was valuable to be able to go back to the recorded lectures as many times as they wanted. Apparently the students find it easier to absorb the material through repeated viewing of the lectures than repeated reading of the textbook. The second most mentioned advantage (a distant second with only 18%) was the increased number of examples during the face-to-face class time. We were surprised by that result. We assumed the examples and in-class homework would be a much stronger finisher. We will try a ranking system rather than a winner-take-all question on the next survey. The winner-take-all type questions result in some obvious answers without getting at the secondary but also important aspects. One student liked that he could watch the lectures from the current semester from anywhere while they were being recorded so he didn’t have to walk across campus for every lecture. Another student liked the fact that we were always using the pen tablet instead of a whiteboard. He said the scrolling action required to use the pen tablet (because the tablet width is so much less than the whiteboard) matched the method the students have to use when they “scroll” down the page of their notebooks.
### Table 1. Likert Scale Question Results

<table>
<thead>
<tr>
<th>Statement</th>
<th>(AS)</th>
<th>(A)</th>
<th>(N)</th>
<th>(D)</th>
<th>(DS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The way the lectures are handled in this course helped me learn the material</td>
<td>39%</td>
<td>22%</td>
<td>22%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>2. The way homework assignments are handled in this course helped me learn the material</td>
<td>39%</td>
<td>30%</td>
<td>26%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>3. The way discussion hours are handled in this course helped me learn the material</td>
<td>39%</td>
<td>22%</td>
<td>30%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>4. The way office hours are handled in this course helped me learn the material</td>
<td>26%</td>
<td>30%</td>
<td>39%</td>
<td>4%</td>
<td>0%</td>
</tr>
<tr>
<td>5. The way laboratories are handled in this course helped me learn the material</td>
<td>44%</td>
<td>26%</td>
<td>22%</td>
<td>4%</td>
<td>4%</td>
</tr>
<tr>
<td>6. The way the design projects are handled in this course helped me learn the material</td>
<td>39%</td>
<td>35%</td>
<td>17%</td>
<td>4%</td>
<td>4%</td>
</tr>
</tbody>
</table>

When asked what aspects of the current format the students didn’t like there was little agreement. None of the comments were offered by more than 20% of the students. The most prevalent comments were:

- No comment.
- The traditional whiteboard method offers no advantages over the current method.
- The current method allows the professor to move through the material too fast.
- The current method required too much video viewing time.
- The live mini-lectures reviewed too much of the prerecorded material.
- The current method allowed students to skip class and fall behind.

A couple of students stated that they didn’t like this course format.

We also asked the students how the current course format could be improved. The spread of answers to this question is even more than the spread in the previous question. Most responses occurred only once hence the results were grouped:
Not sure or no comment was the most common answer at about 20%.

Improve the technical options of the playback was also common (full screen, miniplayer, faster slide transitions, picture in picture).

Students suggested that the recorded lectures should be organized differently. Currently they are organized by date. Students suggested that we organize them by topic and index the content. One suggested shorter videos.

One student each suggested fewer videos with more live lectures, more homework, and more in-depth examples.

The obvious question that the students couldn’t answer in the survey was about how well these students learned the material compared to the students from a control group. The average grades from fall 2012 and fall 2013 are less than 1% apart. Since the standard deviation in each class was about 10% this difference between the averages is not very significant. It appears as though this initial study has done no harm and the study has produced some clear directions for further study.

Clearly the students appreciate access to the recorded lectures, but maybe the recordings should be shorter and more focused, and organized by topic instead of date. That would reduce the overall viewing time and the need for indexing the content of each video. That would also make it easier to keep the in-class mini lectures relevant and not repeat things that were already in the recorded lectures. The time saved during the face-to-face meetings could be used to do more examples and more in-class homework.

Although the students also said they liked the way the homework was handled, we believe we could do more to get them to participate in the in-class exercises. One of the co-authors suggested that the students work in defined groups and collect the students’ work at the end of the class period and connect it to some kind of score. The groups might give the students a sense of identity and ownership and collecting the exercises will give them some incentive to take the exercises seriously.

**Pilot Study 3: Pre-homework assignments, online quizzing, and online discussions**

With the addition of distance students in our courses the faculty workload has increased. To counteract this, we have been looking to make changes that have the potential to improve student learning but also might decrease the long-term workload of faculty. Graded homework was a targeted area for improvement.

We know from experience that students need constant feedback to be successful in engineering. Traditionally, graded homework has provided much of that feedback to engineering students.
The main difficulties with this approach are 1) the limited time/resources to provide feedback to students, which is timely and personalized 2) many students are not doing their own work (either copying solutions from online resources or from other students). As a result, some faculty members have experimented with eliminating graded homework and replacing it with frequent graded quizzes. This approach has been documented in prior papers with mixed results.9-11 From our combined personal experience in teaching (over 40 years), we have found that homework (structured practice with feedback) is essential and that it must be worth at least a small portion of the grade, otherwise only the best students will do it.

Instead of eliminating homework entirely, we chose to focus our efforts on an approach to decrease the amount of graded homework while addressing the feedback needs of those students taking the course asynchronously. As an initial attempt we created a 3rd pilot study to investigate the benefits of using pre-homework assignments, online quizzing12-14, and online discussion to promote student self-directed learning and improve student confidence. The traditional 3-step process (lecture, graded homework, exam) was replaced by a 5-step process for distance students (lecture/reading/video, pre-homework/online quiz, online discussion, graded homework, exam). Although this pilot study included fewer overall students than the other two listed above, it included two additional features. The first was that the class was originated from a remote site. The second was that almost two-thirds of the students took the course remotely.

For the purposes of this study, the traditional lecture content was expanded to include all assigned content (written, audio, or visual) provided either in lecture or outside of class through the class webpage. Lecture content was provided live to the few local students and recorded for asynchronous access by the distance students. To accommodate the larger percentage of distance students one discussion section occurred during the day to meet the needs of traditional students and another occurred in the evening to meet the needs of the nontraditional students. Both sessions were archived. Several short instructional videos were added to the course web page during the semester to assist students with the use of various software packages utilized in the course.

The traditional homework was subdivided into two separate portions, an “ungraded” pre-homework assignment (20% of the homework grade), and a traditional graded homework assignment (worth 80% of the homework grade). The pre-homework assignment consisted of two to three posted homework problems, each having a set of multiple-choice questions with feedback spaced at different substages of the problem to determine if the student had understood the key concepts presented. At the completion of each quiz, the student was provided immediate feedback on their selection(s). Based on this feedback, students were allowed to retake the quiz an unlimited number of times prior to the mid-week discussion session, during which we would go over the pre-assignment problems and address any questions students had in regard to the other homework to be submitted later that week. The only requirement for students to obtain full credit for each pre-assignment was for them to complete the entire quiz once before the
deadline. The student would refer to a set of pre-posted problems and then answer the multiple-choice questions associated with each problem. After completion of the quiz, the student was shown their answers together with brief selection-based feedback.

**Student Survey Data**

One measure of success of the pilot programs can be obtained from student survey data. An anonymous survey was posted on the class webpage at the conclusion of the semester and 45.5% of the students responded. Table 2 shows the survey results for online quizzes. Overall the students found that the use of ungraded online quizzes with individual selection feedback and unlimited attempts was helpful and thought that this practice should be incorporated into future distance engineering courses (all agree or agree strongly). The students found were split on the helpfulness of online quizzes without individual selection feedback (40% agree vs. 60% disagree or strongly disagree) and thought that these problems should remain ungraded (full credit for participation). Specific student comments included “maybe a little more explanation as to why an answer is wrong” and “really liked the feedback” and suggested that we “incorporate one problem from that week’s graded homework” into the online quiz system.

<table>
<thead>
<tr>
<th>Table 2. Online Quizzes Survey Question Results</th>
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<tbody>
<tr>
<td><strong>(AS) Agree Strongly</strong></td>
</tr>
<tr>
<td><strong>(A) Agree</strong></td>
</tr>
<tr>
<td><strong>(N) Neither Agree or Disagree</strong></td>
</tr>
<tr>
<td><strong>(D) Disagree</strong></td>
</tr>
<tr>
<td><strong>(DS) Disagree Strongly</strong></td>
</tr>
<tr>
<td>The ungraded online quizzes with individual selection feedback and unlimited attempts were helpful in this course.</td>
</tr>
<tr>
<td>The ungraded online quizzes with individual selection feedback and unlimited attempts should be incorporated in future distance engineering courses.</td>
</tr>
<tr>
<td>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)</td>
</tr>
<tr>
<td>The online quizzes should have been graded (1 attempt).</td>
</tr>
</tbody>
</table>

Table 3 shows the survey results related to online discussions. The students found that the weekly archived online discussion was very helpful and should be continued in future distance engineering courses (all agree or agree strongly). In terms of the balance of recorded asynchronous lectures to online discussion time most of the students (80%) felt that the current 3:1 split should be retained while (20%) felt the class should have less recorded lecture and more
interactive online discussion time. One student suggested that the discussion section should “focus more on developing our problem solving and a few less examples”.

<table>
<thead>
<tr>
<th>Table 3. Online Discussion Survey Question Results</th>
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<tbody>
<tr>
<td>(AS) Agree Strongly</td>
</tr>
<tr>
<td>Statement</td>
</tr>
<tr>
<td>The Online Discussion section, allowing student-instructor interaction and archived access, was helpful this semester</td>
</tr>
<tr>
<td>The Online Discussion section, allowing student-instructor interaction and archived access, should be utilized in future distance engineering courses</td>
</tr>
</tbody>
</table>

The balance of Recorded SV lectures versus archived Online Discussion Sections:

<table>
<thead>
<tr>
<th>Statement</th>
<th>(AS)</th>
<th>(A)</th>
<th>(N)</th>
<th>(D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>The balance in this class was correct as is:</td>
<td>80%</td>
<td>0%</td>
<td>0%</td>
<td>20%</td>
</tr>
<tr>
<td>We should have fewer archived Online Discussion meetings during the semester &amp; expand the recorded SV lecture time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We should have more archived Online Discussion meetings during the semester but keep the current recorded SV lecture content time as is.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>We should have more archived Online Discussion meetings during the semester and reduce the recorded SV lecture content time.</td>
<td></td>
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</table>

Students were also asked to comment on the usefulness of short videos in the course as a supplement to lecture material. The responders agreed that this was “this was successful and very helpful”. More specifically they thought ‘the walkthroughs with computer programs such as SPICE, Excel and MATLAB were very helpful” and they “should be used in future distance classes.”

**Student Performance**

A total of 8 online quizzes were given during the pilot study (Table 4). The initial quiz for the semester, which was primarily based on review material, required that the student complete the entire 5-question quiz before being given any feedback. Although unlimited attempts were
allowed, very few of the students attempted the quiz multiple times even though they knew their answers for the 2nd problem was wrong (Table 3 Qz1 P2 ?1 and Qz1 P2 ?2). In order to promote student self-directed learning, all future quizzes in the study were set-up as sub quizzes so that students would get immediate feedback after the completion of each subsection of a given problem, allowing them to rework that piece of the problem before moving on to the next part. This change resulted in the desired student behavior (working on the problem until they got it correct). Unfortunately there were a few students in the class who continued to only do the minimum (not taking the time to rework the quiz and resubmit until it was correct which is denoted by the * in Table 4) and their lack of effort showed in their final course grade (none of these students received better than a C-minus in the course).

The solutions of the weekly pre-assignment problems were discussed during the mid-week discussion sessions (one daytime and one evening). During this time, specific questions about the weekly graded homework assignments (due at the end of the week) were also answered. These graded assignments were about 20-25% shorter than normal and were more involved than the pre-homework assignment problems.

The purpose of the online quizzes was to promote student self-directed learning and improve student confidence. Table 5 provides a comparison of student scores as a function of their persistence in their online quiz problems until totally correct given that the quiz provided unlimited attempts. Although the sample size is small, the results indicate that there was some benefit to the pre-homework assignments as long as the students follow the problems to completion.

**Impact on Faculty Workload**

Although there is a substantial initial investment in the creation of online quizzes especially related to the individual selection feedback, there was a substantial payoff in terms of less time spent grading and movement of students toward self-directed learning for both local and distance students. The addition of the online discussion sections added one extra hour of contact time per week (one less hour of lecture, but two extra hours of discussion) were easily offset by a reduced utilization of office hours observed this semester due the combination of the online quizzes and discussion sections. Part of this was due to the design of the online quizzes problems to address specific problem types that students have had problems with in the past. In addition, the higher attendance in live discussion sections per week (55%) with most of the others viewing the archived sessions resulted in a significant reduction of office hours being devoted to homework. This time could be reallocated for laboratory troubleshooting and check-offs to further student understanding.
Table #4  Online Quiz Summary Table (* student(s) not attempting incorrect quiz again)

<table>
<thead>
<tr>
<th>Quiz/Prob./Question</th>
<th>Question Avg.</th>
<th>Avg. Attempts</th>
<th>Max Attempts</th>
<th>Min Attempts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qz1 P1 ?1</td>
<td>81.82%</td>
<td>1.9</td>
<td>6</td>
<td>1*</td>
</tr>
<tr>
<td>Qz1 P1 ?2</td>
<td>100%</td>
<td>1.9</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Qz1 P1 ?3</td>
<td>90.91%</td>
<td>1.9</td>
<td>6</td>
<td>1*</td>
</tr>
<tr>
<td>Qz1 P2 ?1</td>
<td>63.64%</td>
<td>1.9</td>
<td>6</td>
<td>1*</td>
</tr>
<tr>
<td>Qz1 P2 ?2</td>
<td>27.27%</td>
<td>1.9</td>
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<tr>
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<tr>
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<td>1.2</td>
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<td>81.82%</td>
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<td>1.8</td>
<td>3</td>
<td>1*</td>
</tr>
<tr>
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<td>100%</td>
<td>1.1</td>
<td>2</td>
<td>1</td>
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<td>91.67%</td>
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<td>3</td>
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<tr>
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<td>100%</td>
<td>1.2</td>
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<tr>
<td>Qz4 P2 ?2</td>
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<td>1.8</td>
<td>4</td>
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<tr>
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<td>100%</td>
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<td>1</td>
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<tr>
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<tr>
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<td>1.9</td>
<td>4</td>
<td>1*</td>
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<td>100%</td>
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<td>5</td>
<td>1</td>
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<td>1</td>
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<td>Qz6 P4 ?2</td>
<td>100%</td>
<td>1.3</td>
<td>2</td>
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</tr>
<tr>
<td>Qz7 P1 ?1</td>
<td>100%</td>
<td>1.7</td>
<td>3</td>
<td>1</td>
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<td>Qz7 P2 ?1</td>
<td>100%</td>
<td>1.6</td>
<td>3</td>
<td>1</td>
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<td>100%</td>
<td>1.9</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Qz7 P2 ?3</td>
<td>100%</td>
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<td>2</td>
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<tr>
<td>Qz7 P2 ?4</td>
<td>90.91%</td>
<td>1.2</td>
<td>2</td>
<td>1*</td>
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<tr>
<td>Qz8 P1 ?1</td>
<td>100%</td>
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<td>4</td>
<td>1</td>
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<tr>
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<td>90%</td>
<td>1.5</td>
<td>3</td>
<td>1</td>
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<tr>
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<td>90%</td>
<td>1.8</td>
<td>4</td>
<td>1*</td>
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<tr>
<td>Qz8 P4 ?4</td>
<td>100%</td>
<td>1.7</td>
<td>4</td>
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Table 5. Completion of Online Quizzes Qz2 - Qz7 until Correct

<table>
<thead>
<tr>
<th>Correct Final</th>
<th>Graded Homework (%)</th>
<th>Semester Exam (%)</th>
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</thead>
<tbody>
<tr>
<td>Always</td>
<td>80.8%</td>
<td>74.3%</td>
</tr>
<tr>
<td>Most of the time</td>
<td>70.8%</td>
<td>58.3%</td>
</tr>
<tr>
<td>Seldom</td>
<td>42.2%</td>
<td>50.3%</td>
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</table>

Conclusions

All three of the pilot studies to improve the educational experience and student learning for distance engineering students can be deemed successful in that both local and distance students have benefited from the use of the techniques provided and that good student feedback was provided to guide future improvements. The common themes out of these pilot projects are:

1) Students like and will use short demonstration videos especially if they are tied to a piece of equipment/software that is tied to an assignment, design project, or report.
2) Students like the ability to view/review recorded content on demand and it is better if that content is broken down into small chunks (5 -10 minute segments).
3) Students like and will not only complete pre-homework/online quizzes but also engage in self-learning if those problems are broken down into subparts, and the quizzes have unlimited attempts and individual selection feedback.
4) Students like online discussion sessions as a supplement to instead of a replacement for recorded lecture content. They also want these sessions recorded and archived in case they have a conflict or want to revisit the content.
5) Flipping of lecture content is equally acceptable to students, however, the interactive problem solving portion of the class is still a work in progress.

Bibliography


