The Large Lecture Conundrum: A case study in leveraging instructional resources to increase student learning

Harry Pierson
Miami University, Oxford, OH 45056
hpierson@MiamiOH.edu

Abstract

As universities continue to do more with less in the face of modern economic challenges, class sizes are increasing more rapidly than the availability of instructional resources to support them. Simultaneously, all of the constituencies of academia's undergraduate education mission have increased expectations for the quality of instruction. With the scarcity of resources unlikely to abate in the foreseeable future and competition on the horizon from new learning models such as massive online open courses, striving to improve pedagogy in large classes is not just altruistic, but necessary. This paper presents a case study of the author's attempts to bring small-class quality to an Engineering Economy course with an average enrollment of 180 students. The core facet was the practice of using online quiz performance to determine which students were required to turn in weekly homework. This practice fulfilled its original intent, which was to reduce the grading load to a level where weekly homework was practical for such a large class, essentially focusing grading resources on those who needed it most. The unanticipated result was that exemption from turning in homework proved to be a powerful motivation for students to study consistently throughout the academic term. Student learning increased markedly, as evidenced by exam scores and as perceived by the instructional staff. Student satisfaction, as measured by teaching evaluations, also increased. This was accomplished without increasing the time demands on the instructional staff, and in fact, undergraduate grader hours were drastically reduced from previous offerings of the course. Additionally, these strategies scale well to courses with both larger and smaller enrollments.

Introduction

Colleges and universities are struggling under the economic pressure of stagnate or declining funding, increasing costs, and generally increasing enrollments. Engineering programs are no exception, with high demand for engineering talent in industry exerting upward pressure on faculty salaries. Their ability to make up the difference by increasing tuition and fees at rates that far exceed the inflation rate is not sustainable, and many would argue this sustainability limit has already been reached. As such, the general trend is toward increased class sizes with little evidence that would predict a reversal anytime soon.

Given these circumstances, the efficacy of large class sizes in higher education remains of concern. The literature is rich with studies on the subject [1–6], with some studies indicating a negative impact on learning, while others conclude that there exists little correlation between class size and student learning. As one particular review of the literature [7] points out, many of these conclusions are open to debate due to the subjective nature of measuring learning and the quantity and complexity of factors that influence it. While research in this direction is certainly valuable in attempting to sway public policy toward dedicating additional resources toward education, it is of little practical use to administrators and faculty who have limited choice when it comes to the size of the class they must offer or are asked to teach. What is much more relevant for these educators is how to maximize efficacy given large class sizes. Here again, there is no shortage of pedagogical research, but all too often, application of the results lacks sustainability due to limited resources. These limits include limited instructional resources such as teaching assistants and graders as well as faculty time. For the long range, scaling time invested in proportion to class size is simply not a feasible answer in light of already heavy course loads and research expectations for faculty seeking tenure or promotion.

Of the many themes that emerge from this discussion is maintaining a high level of student engagement in a large lecture format. As pointed out rather humorously in [8], engaging with and manipulating the material is key to student learning, especially in the STEM fields. This is why regular, graded assignments have traditionally been a staple of STEM courses. These require that grading resources scale with class size, which is all too often not the case. Faculty generally are not assigned load credit in equal proportion to class size. Graduate assistants are expensive, and quality teaching assistants can be hard to come by in a research setting where the best and brightest graduate students frequently opt for research assistantships over teaching assignments. This motivates a range of compromises, as with reducing the number of assignments or grading only a subset of those assigned. Relegating grading to undergraduate assistants is another. Some instructors abandon graded homework and simply assign ungraded practice problems with posted solutions, leaving responsibility to the students for completion.

While a certain segment of the student population handles this well, many do not. The reasons are many and varied. Students are dealing with their own harsh economic realities, often taking heavy course loads, working outside of school, or both in order to minimize the cost of a college education that has become less affordable with each passing year. Additionally, limited academic maturity may cause students to overestimate what they can realistically handle; some believe that they can salvage success with a marathon study session a day or two before the exam. This practice is occasionally reinforced when it leads to an acceptable grade on a multiple-choice test given by an exhausted faculty member who cannot afford to spend forty hours grading two hundred problem-based exams. Experienced educators understand that this generates little in the way of real learning.

The objective of this paper is to relate some sustainable strategies used by one instructor to improve just such a situation. It was not conceived as a research study, and thus no scientific rigor is claimed. While anecdotal, the results are still encouraging. It is hoped that this paper will inspire adaption, generate discussion, inspire innovation, and motivate in-depth research toward sustainable pedagogical practices for large classes.

Case Study

The setting of the present case study is an Engineering Economy class at a large research university. Enrollment was capped at 180 students per term, but occasionally had to be expanded to 240 to keep up with demand. The course was staffed with one 75% full-time equivalent (FTE) lecturer and one 50% FTE graduate teaching assistant (GTA), and had budget for about 100 hours of undergraduate grader time. The baseline circumstance was ungraded practice problems with weekly quizzes serving as a motivation for students to complete them. Quizzes were a mix of in-class and online, out-of-class assessments, and (bowing to comments on student evaluations) practice problem solutions were posted online after each quiz. Students were asked to complete a project each semester, but it had to be highly standardized and gradable by the staff of undergraduate graders under the supervision of the teaching assistant. This made it less of a project and more of an extended homework project. It was of limited effectiveness and generally unpopular with students. Most disturbing of all, it was quite apparent that many students were not completing the assigned practice problems. Some would obtain solutions from a friend who had previously taken the class or wait until they were posted. This led to giving up on a problem too easily and jumping to the solution at the first sign of frustration. Others would simply read over the problems and solutions the night before the exam. This situation manifested itself in poor exam scores, especially on the first exam, which covered foundational material (time value of money) that served as the basis for the remainder of the course. It was also observed from questions asked in class and during office hours that a large number of students simply were not learning. Quizzes, which together accounted for 10% of the students' grade, were evidently not a sufficient motivation. Further, if a student performed poorly on a quiz, there was no external motivation to revisit the material prior to the exam.

Clearly, weekly graded homework was needed. It was equally clear that the available grading resources were not being effectively used, but were still insufficient to implement weekly graded homework for the entire class. This led to the key question of how grading resources can be directed to the students who needed them most. This inspired an unconventional solution: Use quiz performance to determine which students needed to turn in homework. The typical GTA load in the department involved grading weekly homework for a class of 40–50 students. By dropping the course project and setting a threshold on quiz performance, the intent was to focus the GTA's time on the 25–35% of students who needed it most. Quizzes were moved to 100% online to conserve grading resources. They consisted of five to ten questions over current material with time limits of 15 to 45 minutes based on the number and difficulty of the questions. Quiz questions were presented at a similar level of difficulty to practice problems and exams. The policy was simple – meet the threshold on the quiz and get an automatic 100% on the week's homework. Students who did poorly on the quiz were thus encouraged to reengage with the material immediately.

Without a computer lab that could accommodate 180 students, online quizzes were out-of-class, raising concerns of academic dishonesty. It should be noted, however, that a lecture hall with hundreds of students packed shoulder-to-shoulder carries its own cheating risks. The syllabus dealt with this by prohibiting discussion of the quiz between students. Otherwise, books, notes, and spreadsheet software were allowed. Students were cautioned that these resources would not be available on the exam.

In tandem with this change, an entirely new set of practice problems were selected, and while students were given numerical answers to the problems, the policy of posting solutions was discontinued. Students were politely told that the instructor and GTA would be happy to help them during office hours or on the online discussion board if they became stuck, though it was their responsibility to persevere until they arrived at the solution. Additional office hours for both the instructor and the GTA were scheduled to accommodate the anticipated increase in student demand for help.

The new system was rolled out with the start of a Winter 2012 term. The results exceeded expectations.

Results & Discussion

Class average for each exam is shown for the period Autumn 2010 through Summer 2012 in Figures 1–3. Each exam (1, 2, and final) covered the same objectives each term, albeit the specific questions changed each quarter. In Table 1, the mean and standard deviation of the pre-change data (Autumn 2010 through Autumn 2011) are computed assuming a normal distribution. Table 2 presents the post-change data in terms of standard deviations above (+) or below (-) the pre-change mean. The data shows a clear increase in exam 1 performance, a smaller increase for exam 2, and a decrease in the final exam performance. Unfortunately, this data was collected after the fact. Since it was not planned as a research study, there was no purposeful experimental design employed to control other factors or ensure statistical significance. Still, the results for exams 1 and 2 are encouraging; the final exam less so. It is conceivable that with the class entering the final exam with higher grades, students focused their efforts on the finals in their other courses. Additionally, the Summer 2012 term was compressed into seven weeks from its normal ten, which may explain the poor results on that final.

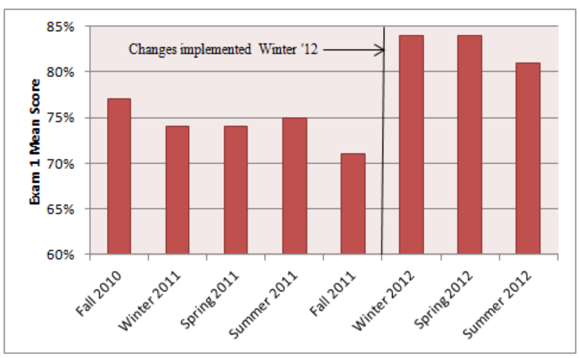

Figure 1. The mean of the scores on the first exam improved markedly.

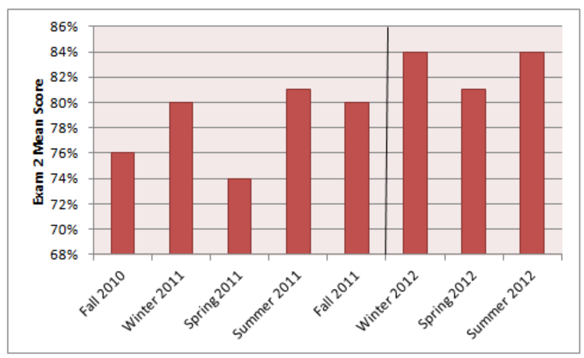

Figure 2. The second exam scores showed improvement, though less dramatic.

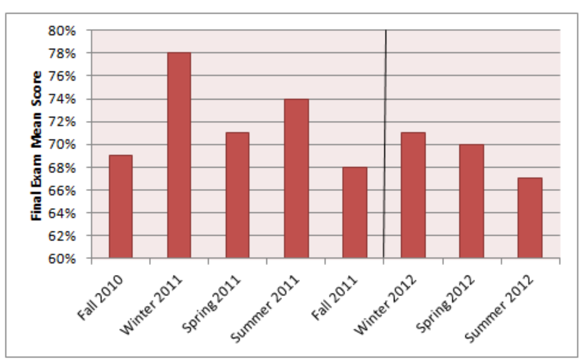

Figure 3. A slight decline in final exam performance was observed.

Table 1. Mean and standard deviation of exam scores before the change. A normal distribution is assumed.

	Exam 1	Exam 2	Final
Mean Score	74.2%	78.2%	72.0%
Std. Dev.	2.2%	3.0%	4.1%

Table 2. Exam scores after the change, expressed in terms of the number of standard deviations above or below the mean of the pre-change data.

	Exam 1	Exam 2	Final
Winter '12	+4.5	+1.9	-0.2
Spring '12	+4.5	+0.9	-0.5
Summer '12	+3.1	+1.9	-1.2

More subjectively, both the instructor and the teaching assistant noticed a difference in the students. Fewer students were "lost," and questions during office hours and class reflected a deeper understanding of the material. This was despite academic dishonesty concerns associated with out-of-class quizzes. While it would be naive to believe that cheating did not take place, the observed overall improvement tends to suggest that on the whole, students' engagement with the material had increased.

Objective feedback also made it clear that the new quiz/homework policy was immensely popular with students: Student comments indicated that the students appreciated being given responsibility for their own learning; that if they could demonstrate their mastery of the material, they did not have to spend their time doing homework problems. Comments also indicated that the new policy provided a strong motivation for students to study at a regular pace throughout the term by creating a stronger up-side incentive without increasing down-side consequences for students who were struggling. Students were so motivated to avoid homework that they invested more time and energy in the practice problems. A list of student comments from a small-group instructional diagnostic (SGID) pertaining to the quiz/homework policy is provided in the appendix.

The decision to stop posting practice problem solutions appeared have the desired effect of causing the students to engage more fully with the material. However, there were also some surprising results. First, the surge in demand for help never materialized. Office hours were not perceptibly busier after the change, nor did traffic on the online discussion board change much. It is postulated that the new policy incentivized starting the practice problems early and planning ahead. In the hours between getting stuck on a problem and the next available office hours, the students had an opportunity to think about the problem and often found the answer themselves. Even more surprising, there was very little backlash from the students. After a little resistance the first quarter (Winter 2012), responses on course evaluations actually improved (Fig. 4). Moreover, the written comments from the Spring and Summer 2012 terms did not contain a single comment requesting the posting of practice problem solutions. This was likely due to establishing the policy and expectation early in a friendly tone that emphasized that the policy was for the students' benefit and not an attempt to be coy. The following quote is from the course syllabus:

> "For each topic covered in lecture, practice problems with final answers but without full solutions will be assigned but not collected. Research indicates that the effectiveness of practice problems is greatly enhanced when students make a full and complete attempt to solve them before resorting to looking at the solution. To encourage this, lists of solutions will not be posted online. Of course, from time to time everyone gives a problem their best effort and still gets stuck. The staff is happy to provide solutions to individual practice problems by request, either in office hours or on the discussion board."

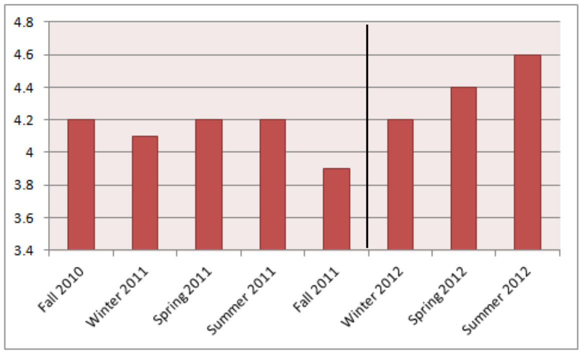

Figure 4. Overall rating on student evaluations of instruction increased as measured on a Likert scale of 1–5.

Conclusions

In summary, it appears that the quiz/homework policy presented herein had a positive effect on student learning. It is important to note that the data was collected after the fact when it became apparent the changes were successful, and lends itself to the formation of a hypothesis for future research – not to conclusive results. Further, there is at least anecdotal evidence that students' reliance on homework solutions can be broken without sacrificing student satisfaction. Perhaps the key lies in students' success negating the perception that they are being put at a disadvantage. Finally, the strategies presented were sustainable in that they did not change the time the instructor spent on the class and did not require additional resources from the department. In fact, undergraduate assistant hours were reduced to a small fraction of their previous level, saving money. The strategies also scale very well: The same instructor could teach double the class size with two 50% GTAs, or a class half the size with a single 25% FTE GTA.

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Appendix

The following student comments regarding the new quiz/homework policy were extracted from a small-group instructional diagnostic (SGID) conducted in the Winter 2012 term. Thirty-two groups responded.

From the report summary:
"There was virtually unanimous agreement that the homework/quiz policy helped students learn, although one student criticized it as 'double punishment'."

Relevant student responses to the question, "What are the strengths of the course and instructor that assist you in learning?":

- "Having weekly quizzes forces students to stay on top of material"
- "Homework is not mandatory"
- "Doing well on quizzes gets credit for homework"
- "Rewarded for doing well on quiz, don't have to do homework"
- "By doing well, homeworks can be skipped"
- "The way we only have to do the homework if we get below an 80% on the online weekly quiz is nice. We don't have to waste our time if we clearly know the material after studying."
- "Quiz/homework system is very good"
- "Weekly quizzes"
- "No HW"
- "The quiz/HW format is nice."
- "Quiz/homework system works well."
- "Quizzes/HWs are very helpful to keep pace with learning"
- "The homework is really nice if we get an 80% on the quizzes"
- "Structure of how the homework and quizzes are set up"
- "Quizzes keep you on top of work – being able to avoid graded hw is an incentive"
- "Quiz/homework system"
- "Doing well on quizzes get you out of homework. This is awesome."

Relevant student responses to the question, "What things are making it more difficult for you to learn?":
- "No required HW makes quizzes difficult sometimes"
- "Quiz & HW"

Relevant student responses to the question, "What specific changes would you recommend to the instructor that would assist you in learning?":
- "Having to do HW after messing up the quiz is double punishment"
- "Make HW extra credit if quiz > 80%"