121st ASEE Annual Conference & Exposition
Indianapolis, IN
June 15-18, 2014
Paper ID #8658

Teaching Time Value of Money: A Few Winning Strategies from the Front Lines

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Abstract

Like most professors, we are constantly making changes to our classes by using new texts, trying new teaching techniques, and experimenting with new modes of instruction. Sometimes these changes do not work very well, and we discontinue or revise them until they work. Sometimes they work so well that we would like to share our experience with others to repay the debt we owe to the many who have described what has or has not worked for them.

This paper captures some of our more successful examples in teaching courses about the time value of money. Each of the authors has tried to improve student engagement. We believe that this contributes to improved learning in subjects that many students consider boring. Each author teaches at a different university with varying class sizes and diverse student groups. Each of the three perspectives shared here is therefore unique, and each offers a different set of ideas for engineering economics and finance instructors. Strategies include the use of memorable metaphors, spreadsheet based learning, clickers, online homework, teaching in computer labs or with a student laptop requirement, and assignments with high relevance to students. Recommendations for application in a variety of settings are discussed.

Introduction

Engineering students often have difficulty with core concepts in their coursework. Without overcoming these difficulties to master the conceptual material, advancing in the course and learning new material may be hampered. Economic concepts receive less focus in engineering curriculums and tend to be correspondingly less familiar to engineering students. While the mathematics required is not particularly complex, the concepts of the time value of money, discounting cash flows, evaluating the worth of mutually exclusive alternatives, etc. do require time to absorb. This is exacerbated by the fact that such problems are often presented in textual format (the dreaded “word problem” format) where a slight change in the wording can dramatically alter the intended interpretation. A student that struggles with these concepts is at an increasing disadvantage as the course progresses and new material builds upon these concepts. A student that is less skillful at parsing word problems is further disadvantaged.

Success and progress through the engineering economy and other time value of money courses is the focus of this paper. However many of our points are also relevant to the larger problem of the efficient progression of engineering students through the STEM pipeline which is of great importance to educators. The supply and quantity of STEM graduates has a direct impact on the competitiveness of a nation[1]. Students that perform poorly in a course or must repeat it are at a greater risk of dropping off the STEM track and may require longer to graduate. This in turn has serious economic impacts for students that are on some sort of financial aid to finance their college education. As of December, 2013, the total value of outstanding student loan debt in the U.S. has reached $1.08 trillion with 11.5% of all student loans in technical default by 90 days[2]. This level of debt may have crushing impacts on the future financial prospects of indebted students as they struggle to pay off the loans while establishing themselves. This larger problem can provide a vivid example for the many students that can use engineering economy to analyze their student loans.

Instructors that teach these subjects have to find the right set of methods to assist students in grasping the concepts, understanding them deeply enough to apply the concepts, and being ready to take the next step into engineering decision-making.

Literature Review

Wittrock[3,4] crafted the theory of generative learning noting that students gain greater learning when participating actively in the educational process as opposed to passive participation. When they are actively engaged, students are better able to make sense of the information being transmitted and fit it into the framework of their prior understanding. This leads to stronger associations of the material because the students are accessing memories from long term memory and increases the likelihood that the new conceptual material will be better absorbed itself into long term memory. Bruner[5] created the theory that students learn by building new knowledge through activities and guidance from supportive experts that serve as instructional "scaffolds" for the new concepts. Lee, Lim, and Grabowski[6] conducted a review of generative learning literature that indicated students are better able to remember, understand, and utilize higher order knowledge about new concepts when they are active participants in the learning process. The following subsections discuss a set of pedagogical techniques to encourage active learning.

Homework

Homework may be assigned to try and ensure that students work with the material, develop a deeper understanding, and practice the mechanics before they have to demonstrate their competence on an exam. Other instructors may state that doing problems is the only way to truly learn the material, but they may simply list suggested problems while collecting and grading none. The tradeoff for faculty, especially with large classes, is whether the students get sufficient benefit to justify the resources used in administering it. If homework is not collected and graded, it often isn't done as students prioritize their effort to the most immediate requirements.

One approach to administering homework that simplifies the collection, grading, and logging of scores is to construct or use publisher supplied online, automated assessments. Taraban, et al.[7] studied the effects on exam performance of using online homework assessments and determined that the amount of time students spent working the assessments was directly related to their achievement on exams. Bennett et al.[8] found a strong correlation between the inverse of the number of attempts students made using online homework assessments and the degree of competence achieved in the core concepts.

Engagement in Lectures

Student response units (a.k.a. "clickers") are one technique for stimulating student engagement and promoting the grasp of difficult material. Clickers were first used in the 1960s[9]. They've been shown to enhance learning when teaching quantitative material in math and science courses with large enrollment sizes[10 11 12]. Studies have shown that clickers lead to higher levels of student engagement and active learning[13 14]. Answering questions posed by instructors gives the students a chance to see how well they've grasped core concepts so that misconceptions can be corrected faster and well before exams[15 16]. Seeing the overall class responses gives instructors a chance to identify when a concept hasn't been well-understood so that additional examples can be offered. Ozungor & Guthrie[17] and Dornisch & Sperling[18] found that instructor questions which assessed students' deeper conceptual understanding were of greater benefit in final exam performance than questions which merely called for reciting dry facts. Dawson, Meadows & Haffie[19] reported that students' course grade was positively associated with their performance in answering clicker questions in class. Students that demonstrated greater engagement by answering questions more frequently tended to get more answers right and achieved better course outcomes.

Another factor is simply keeping students' interest. Dry, uninvolving lectures where students feel little interest has been cited by Seymour and Hewitt[20] as one factor in students deciding to leave STEM for a different major that may hold more appeal. Students find it harder to stay engaged when the material being discussed is highly theoretical and the connection to practical application is not apparent.

Practical Experience with Different Assignment Methodologies

This section will focus on homework: solution tools—particularly spreadsheets, use of on-line homework, and a short concluding section on increasing the material's relevance to students.

Spreadsheet Based Learning

The use of spreadsheets to teach engineering economy is not new. In 1989 the first casebook in engineering economy was published[21]. In 1992 three new engineering economy texts included spreadsheet modeling methods. Kahl and Rentz [22] was dedicated to spreadsheets. The other two, Park[23] and Eschenbach[24] are available in more recent editions. The efficacy of spreadsheets and factors has also been compared [25, 26]. Needy, et al.[27] and Nachtmann, et al.[28] document the increasing use of spreadsheets in teaching engineering economy. However, texts and most teaching seem to have continued to rely heavily on the use of engineering economy factors in spite of a continuing series of calls for less financial arithmetic. Much and perhaps nearly all of this described spreadsheet use was for more complicated problems, such as inflation, taxes, or cases. In 2011, 36 leading engineering economists cosigned a proposition on using tabulated factors[29]. This was accompanied by Eschenbach and Lewis[30], which also described the use of spreadsheets for more basic problems.

One of us has been teaching a graduate engineering economics course for the past several years. The course is an elective, offered once per year in the Technology Management department. Most students have not previously had engineering economy, but most previously completed a finance course, and so have had an introduction to time value of money, depreciation, and taxes. Student who enroll in the course typically have done very well in the finance course. The course was previously taught in a conventional classroom, using conventional teaching methods, including interest tables and engineering economy factors. Financial calculators were required and used throughout the course. For the last few years, the use of Excel was introduced. Tests were given in a computer lab, and students had their choice of tables, financial calculators, or spreadsheets to solve time value of money problems. Despite the fact that the tests were administered in a computer lab, class delivery was in a classroom and focused on conventional methods and financial calculators.

In spring 2013, the course was moved to a computer lab early in the semester. Every student had their own computer with Microsoft Excel. Because everyone had ready access to Excel, the teaching approach in the course significantly changed. The use of engineering factors was abandoned in favor of spreadsheet financial functions. The use of financial calculators also decreased in favor of using spreadsheets. The approach to solving problems shifted to focusing on problem solving strategies based on spreadsheets, which was a significant change. Much less time was spent doing financial arithmetic, and more time was focused on setting up problem solutions. This increased time on solution strategies caused the students to understand the material better. Arithmetic gradients, which are a favorite of textbook authors but rarely occur in actual engineering practice, were largely replaced with geometric gradients and solved using spreadsheets and block financial functions (the NPV and IRR functions). Other types of problems tended to be much the same as they were in the conventional classroom, but spreadsheet based solutions were quite different. Much less class time was spent doing financial math. Much more time was spent on how to set up problem solutions.

5-button calculator. One of the tools that was introduced to the class is the 5-button calculator. This is not a physical device, but rather a spreadsheet format that uses a personal computer to perform in a manner similar to a financial calculator. The format is easy to remember and is intuitive to use. This approach was originally developed to show students the expected inputs and outputs of time value of money homework problems that were done with financial calculators. It is used extensively in Newnan, Lavelle, and Eschenbach[31]. Figure 1 demonstrates the use of the 5-button calculator format for a sample problem.

Assume that you are a student who owes $29,400 when it is time (6 months after graduation) to start repaying your 6.8% federal Stafford loan. a) What is your monthly payment to pay this loan off in 10 years? b) If you increase your payment to $500 monthly, how many months does it take to pay the loan off? The monthly interest rate is best entered as “=6.8%/12” in the interest rate cells (B2 and B4). Note that solving this with tables requires interpolation for both answers and repeated iterations for part b).

Figure 1. Loan Payment Example

	A	B	C	D	E	F	G	H	I
1	ID	*i*	*N*	*PMT*	*PV*	*FV*	Solve for	Answer	Formula
2	Fig. 1a	0.567%	120		29,400	0	PMT	-$338.34	=PMT(B2,C2,E2,F2)
3									
4	Fig. 1b	0.567%		-500	29,400	0	N	71.72	=NPER(B4,D4,E4,F4)

Students quickly learned this technique, used it to solve a wide variety of problems, and liked this approach to solving problems. In one test, it was noticed that at any given time about one fourth of the students had a 5-button calculation showing on their computer monitor. This format made calculation easy once the problem was properly set up by them. Just like when using traditional engineering economy factors, we believe and teach our students that an initial cognitive step of reading the problem and drawing the cash flow diagram should precede the calculation step.

Cases. Several engineering economy cases were also used, where students would work in teams to solve a larger problem and present their solution. Spreadsheets are required in order to solve the more complex problems such as sensitivity analysis. Problems were chosen either from a case book[32] or created. The Social Security cases that were presented at ASEE concerning singles[33] and couples[34] were class tested in this way. The cases are significantly more complicated than standard end of chapter problems, giving the students an idea of how course concepts are applied in the working world. The ability to solve realistic problems using spreadsheets has resulted in students being offered jobs.

Outcomes. The Spring 2012 course had 30 students and was conducted in a classroom (with 2 tests conducted in a computer lab). The Spring 2013 course had 20 students with most of the semester in a computer lab. While the tests in the two semesters were not identical, they were intentionally similar so that the two teaching approaches could be compared. The average grade across the two tests in 2012 was 89.25; for 2013 it improved to 91.87. This is a statistically significant difference at $\alpha = 0.05$. It should be noted that these grades are reasonable for a graduate course since a C is generally considered unsatisfactory at the graduate level. As a measure of practical significance, the experienced instructor's assessment of student quality is that the latter class was on average a weaker group—which makes their better performance even more significant. The students learned the material in a better way using modern tools, in a way they will remember better, and in a way that will help them get a job. This is far more important than the improved test scores.

The students were highly engaged in the 2013 class; they felt that learning the material using spreadsheets was a job skill that they could market. This was reflected in a brief questionnaire at the end of the semester, as shown in Table 1. Of the 20 students, 19 preferred using spreadsheets to conventional methods (one preferred using traditional engineering factors). Voluntary comments were strongly supportive of the spreadsheet approach. Based on these results, the Spring 2014 course is being held in a computer lab.

Table 1. Student Responses to the Computer Lab

Question 1a and 1b (N=20)	What is the value of using Excel in class?		What is your recommendation regarding having class in a computer lab?
A: It is the reason I will successfully complete this class	80%	A: It really needs to be done this way in the future	90%
B: Excel was helpful	15%	B: It's nice but not required	10%
C: Neutral	0%	C: Neutral	0%
D: I prefer other methods	5%	D: Not very helpful	0%
E: A waste of time	0%	E: Don't do it; go back to a regular classroom	0%

Online Homework

Knight, Nicholls, and Componation[35] discussed the process of instituting instructor developed online homework assignments and measuring their effect on students' exam performance. Successful completion of a key homework covering essential core concepts prior to Exam #1 was a significant predictor of earning 80% or better on Exam #1. The homework was conducted by assigning textbook problems in advance and then posing questions about the problems in an electronic "survey" assessment posted in the Learning Management System (LMS) used for the course. The possible answers to the questions were all multiple choice including some "distractor" answers that students might select if they made certain standard errors. Students had the opportunity to work the problems in advance of logging in to LMS to take the survey. Once they started the assessment they had a limited amount of time (usually 90 - 120 minutes) to answer the questions. This allowed them some time to rework the problems during the assessment if none of the potential answers available matched their initial results. After completing the assessment and submitting it electronically, the LMS graded the assessment, provided the score, and indicated which responses were incorrect. With the knowledge of which problems had been wrong on an earlier attempt, students were able to repeat the assignment up to three times. The potential answers were reordered randomly each time but were not algorithmically randomized. Thus each attempt was done with the same problem parameters. The students' average score was recorded in the LMS gradebook as their final score for that assignment.

Data were gathered from three sections of engineering economic analysis taught by one of the co-authors at the University of Alabama in Huntsville (UAH) from Fall 2011, Spring 2013, and Fall 2013. Online homework with automated grading had been used in Fall 2011 and manual homework with manual grading had been used in 2013. The number of students that completed the class each semester varied from 77 (a double-sized section) in 2011 to 41 and 37 in Spring and Fall 2013, respectively. For each student in these sections, the number of homework assignments missed, the homework average score earned, and the overall course score were collected. The mean number of homework assignments missed was lowest in the Fall 2011 section and the mean homework average was the highest in that section. Statistical testing indicated that both the mean and the standard deviation in comparing the number of homework assignments missed and the mean homework average were significantly different at the $\alpha = 0.05$ level (the on1ine homework section did better). The overall course average did not show a significant difference suggesting that other course components exercised a greater influence than homework which was only weighted at 10% of the course. The students in the Fall 2011 section exhibited a significantly greater homework participation which prior results indicate can lead to better performance on the critical first exam[36].

Another co-author has had more limited experience with online homework from teaching finance courses. That experience has been extremely positive, and students have been nearly unanimous that the use of online assignments should be continued (in spite of it adding up to $95 to the cost of a used text). Students have done better on specific exam question types (two step calculations). Far less time has been spent going over the homework, which means there have been more time for lecture and other activities. Average performance on online homework is well over 90% (often over 98%). It is possible that some of the difference in instructor experiences is due to a difference in student diligence and persistence while doing homework (online matters more for business students who have been less diligent on average). Another possibility is that the functionality available on publisher developed platforms to allow students to repeatedly attempt homework problems with help screens or links to an e-text produces better results than that obtained through instructor developed materials administered through a LMS.

Homework Assignments with Greater Relevance to Students

Students tend to learn more when the assignments have relevance for them. A very abstract example that holds no interest or meaning for them may produce learning of how to execute the mechanics of the analysis. On the other hand, an example that shows them how to analyze a financial decision they may well face in the near future is more apt to be thought-provoking.

For instance, an example problem discussing a potential loan to buy equipment for making widgets may teach students how to convert the value of a loan's principal into the monthly payments required to pay it off over the loan's term. However, an example that shows them how to figure the monthly payment on a car loan, a home loan, or a student loan is closer to their personal experiences and may more deeply engage their interest in learning the technique. A homework assignment that included a problem requiring the students to calculate the value of a student loan debt at graduation and the resulting monthly payment over the repayment term got students more engaged. Several reported that they hadn't really considered before how the payments were calculated, what the impact on their post-graduation disposable income would be, or how expensive taking an extra year to graduate could be. This wasn't a particularly pleasant learning experience for many of them, but the students had a new appreciation for the serious decisions they were making through financing their investment in a college education.

Practical Experiences in Engaging Student Interest

Memorable Metaphors

Students have a remarkable ability to tune out professors during lecture. This was true even before the advent of laptops, cellphones, electronic tablets, etc. Now there are many potential distractors that a lecturer must compete with. One way to get students to stop texting, look up from their iPads, or turn down the volume on their iPods is to employ vividly memorable metaphors during lecture.

For example, one of the most challenging topics for students to grasp in engineering economic analysis is incremental rate of return analysis. Understanding what a project's internal rate of return is and how to calculate it is quite difficult, let alone grasping what it means and how to interpret the results for decision-making. Conveying to students that the best alternative from a set of mutually exclusive alternatives cannot be chosen based on the highest individual rate of return and that incremental analysis must be performed is especially hard. During one particular lecture a majority of the students had developed that all too familiar eyes-glazed, slack-jawed expression of person who has drifted into mental screen-saver mode. A snap decision was made to pull them back to alertness with an analogy so vividly shocking that they couldn't ignore it.

Incremental rate of return analysis with investment alternatives involves an iterative process of successive two-alternative comparisons to see if an alternative with a more expensive initial investment cost delivers sufficient incremental benefits to warrant choosing it over the less expensive investment alternative. This is rather like an athletic competition that is settled with a tournament except that the alternative with the lowest initial expense starts out as the “Defender” and remains the default choice until a “Challenger” alternative proves superior and replaces it as the new “Defender”. There isn’t a parallel set of games between other alternatives taking place simultaneously. A combat analogy was suddenly envisioned to try to get the concept across.

Thus the process of successive Defender/Challenger comparisons was explained using the analogy of gladiatorial combat from the days of deadly games in the Roman Coliseum. The lowest initial cost option is pushed into the ring holding a sword and told to defend himself against the incoming competitor. The next most expensive alternative is sent into the ring as the Challenger holding a spear. The two do battle [the instructor acts out the cut & thrust motions to the bemused expressions of the students.]. Depending on how the example problem has been set up, either the Defender beheads the Challenger to win the match or the Challenger impales the Defender to become the new Defender. [Students abruptly jerk upright to the unusually vivid statements and slightly shocked laughs/gasps of their fellow students.] Getting further into the drama of the analogy, the instructor calls up more imagery from popular fictional depictions of gladiatorial fights. The instructor “narrates” that the crowd goes wild as the victor celebrates the win while the loser’s corpse is dragged out of the ring. [Students’ eyes snap wide open as they listen to the play-by-play, getting the idea, and yet perhaps wondering if their instructor is feeling alright.] The next most expensive alternative is sent into the ring, and combat continues until the last project alternative standing alive is the overall choice. The students laugh, but they remember the analogy and have better recall of the technique on exams.

To illustrate the effects of this technique, results from two similar sections have been compared. The scores for each student in answering an incremental rate of return exam problem were recorded for both sections. The Spring 2011 section was taught before the gladiatorial combat metaphor was employed and the Spring 2013 section occurred after this metaphor had been in use for several semesters. In Spring 2011 there were 41 students that took Exam 3. Their scores on the incremental rate of return problem as a percentage ranged from 0 to 100%. The average was 68%, the median was 80%, and the standard deviation was a disheartening 34 %. In Spring of 2013 a total of 33 students took Exam 3. Their scores on the incremental rate of return problem again ranged from 0 to 100%. The average for this semester improved to 77.65% and the median increased to 100%. The standard deviation was slightly reduced to 28.98. The means were statistically different at the $\alpha = 0.10$ level. Interestingly, in the past several semesters, a handful of students have found the metaphor sufficiently memorable that they have sketched cartoon imagery on the exam with the “gladiators” marked with the appropriate design alternative names from the problem. In each case, these students have correctly answered the problem. This particular analogy may not be suitable for all audiences or teaching styles, but the technique of using vivid, memorable metaphors is easily adopted.

Clicker-Supported Lectures

Two of the authors have been using clickers in undergraduate and graduate introductory finance classes and engineering economy classes at the University of Alaska Anchorage and at the University of Bridgeport. Past surveys of both undergraduate and graduate student classes found that over 80% of both sets of students found the clickers beneficial[37].

More recent results confirm our previous results that clickers are valuable in both qualitative and quantitative courses. Clickers were used in three graduate courses, all taught by the same faculty member. One course was qualitative in nature (N=28), a second course was a management course considered 1/3 quantitative and 2/3 qualitative (N=10), and the last course was a graduate introductory financial class (quantitative) (N=18). The students in the three courses were surveyed and the results reported were similar between the three classes as well as to past quantitative course results.

As shown in Table 2, over 75% of the students reported that the clickers were beneficial in learning the course materials. Students are most supportive of the use of clickers in more quantitative courses.

Table 2 Student Responses to the Question "What was the Value of Using Clickers?"

Question 2	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)	Total Graduate Course Average (N=56)
A: They are the reason I will successfully complete this class	3.6%	10.0%	5.6%	5.4%
B: They were helpful in my learning	75.0%	80.0%	94.4%	82.1%
C: Neutral	21.4%	0.0%	0.0%	10.7%
D: Using fewer would have been better	0.0%	10.0%	0.0%	1.8%
E: They were a waste of time	0.0%	0.0%	0.0%	0.0%

As shown in Table 3, a major impact of clickers is that students learn from their mistakes. They also help the student to stay engaged in class. Students have admitted that they cannot mentally drift off because they never know when a clicker question might come up. With greater attention and commitment to providing an answer (right or wrong) students are more involved in the class, creating a form of dialogue. As would be expected in the qualitative course, students responded 0% to the answer that clickers allowed them to "preview calculations for the homework".

Table 3 Student Responses to "What is the Biggest Advantage of the Clickers?"

Question 3	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)*	Total Graduate Course Average (N=58)
A: Previewed calculations for the homework	0.0%	20.0%	5.0%	5.2%
B: I learned from my mistakes	53.6%	50.0%	65.0%	56.9%
C: It forced me to wake up and respond	46.4%	30.0%	30.0%	37.9%
D: Instructor was quiet for a while	0.0%	0.0%	0.0%	0.0%
E: There weren't any advantages	0.0%	0.0%	0.0%	0.0%

*Some students gave multiple answers to multiple questions.

Clickers do slow the pace of the class. Dialogue takes longer than monologue. Less material can be covered in the same amount of time, but the level of learning is greater. The top students may not be *exposed* to quite as much material, but students *master* more material. Overall, student learning is greatly enhanced, and the grades earned tend to be higher. When surveyed, students recommended the use of clickers in spite of the added cost, as shown in Table 4. The majority of the students in the three courses responded that they would strongly recommend the use of clickers in their respective course in the future.

Table 4. Student Responses to "Would you recommend using Clickers in this course again?

Question 4	Graduate Course Qualitative (N=28)	Graduate Course 1/3 Quantitative 2/3 Qualitative (N=10)	Graduate Course Quantitative (N=18)*	Total Graduate Course Average (N=56)
A: Yes, strongly recommend	67.8%	70.0%	88.9%	75.0%
B. Yes, but not strongly	28.6%	30.0%	11.1%	23.2%
C. Neutral	3.6%	0.0%	0.0%	1.8%
D: No, but not strongly	0.0%	0.0%	0.0%	0.0%
E: No, strongly do not recommend	0.0%	0.0%	0.0%	0.0%

*Some students gave multiple answers to multiple questions.

Feedback Matters

A common thread of online homework, teaching in a computer lab, and clickers is the value of quick feedback in student learning. This quick feedback helps students stay engaged, and it supplies real-time indications of what has and has not been understood. Particularly with clickers there is also feedback to the instructor on how many have or have not understood a concept or calculation. This fast feedback is in contrast to the slower feedback on instructor graded homework, projects, and exam.

One of us has taught using clickers for nearly 25 years and has used clickers in nearly every class for the last 10 years. Three semesters ago there was the opportunity to move a class into a computer lab. Coincidentally, this was the first semester that the instructor decided to rely principally on online homework after a trial run of online homework had been very enthusiastically received the previous semester. Thus this class had quick feedback in class from clickers. Students were able to see if their work matched the instructor's for spreadsheets, and then for homework, students received instant feedback, suggestions, links to text sections, and multiple tries to get it right.

The results were so good, that a talk on the "Best Teaching Experience of my 35-year Career" was planned. Two subsequent semesters have not been as positive, but as shown in Table 5 for this instructor using 3 methods with quick feedback rather than only clickers dramatically improves average class performance

Table 5. Number of fast feedback mechanisms for class

Clicker only	A	B	C	D	W	
Spring 2010	11	7			3	
Spring 2011	5	4	2	1	2	
Spring 2012	5	8	3			Avg. GPA
	21	19	5	1	5	2.98
3 Feedback						
Fall 2012	10	3	(Best class ever)			
Spring 2013	5	7				
Fall 2013	4	2				
	19	12	0	0	0	3.61

These results are particularly impressive because of an accompanying shift in course scheduling. The clicker only sections were taught with a 30 class session schedule (15 weeks of two class sessions per week). The computer lab sections are being taught in a 12 class session schedule (12 weeks of one session per week). Most experienced instructors would agree that student learning tends to be enhanced with more frequent and shorter class sessions.

Conclusions

Engaged students that perceive relevance in the lectures and assignments are more apt to think critically about the material, actively work to grasp it, and exhibit better retention of the core concepts. Rather than playing smartphone app games or texting with friends, they're more likely to be figuring out how the content applies to their work and personal lives. There are multiple strategies that can be employed to create this type of learning environment instead of a static learning environment where students are too often bored, disengaged, and learning very little.

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