

Lather, Rinse, Repeat: The Effect of Replacing Homework with Periodic Quizzes in Engineering Courses

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Abstract

This paper investigates the benefits and consequences of eliminating graded homework assignments in engineering courses and replacing them with ungraded study problems and short periodic in-class quizzes. The specific environment for this study is the US Military Academy, West Point, NY. West Point has several unique factors related to curricular requirements and student time commitments which motivated the authors to strive for increased time efficiency in learning complex material. The authors of this paper have taught engineering courses under both course models, and this paper outlines the benefits realized by switching to a course structured around study problems and quizzes in lieu of assigned homework problems.

Introduction

Traditionally, most engineering professors assign graded homework as a method of ensuring their students are practicing problems to gain an understanding of the course material. Homework also provides professors with a form of feedback assessment and a means of student performance evaluation. However, is homework absolutely necessary in engineering classes for our students to achieve these three objectives: comprehension, feedback, and student evaluation? Based on our observations and statistical data, we concluded that homework assignments can be replaced with recommended study problems and short in-class announced quizzes given over various periodicities. After teaching three separate electrical engineering courses at the United States Military Academy under both course models, we concluded that the benefits certainly outweigh the costs.

Literature Review

A civil engineering multicourse study found that quiz performance was correlated to test performance, and homework performance had little correlation for most courses, and only moderate correlation in one course¹. Their study included graded homework and fewer quizzes than our proposal. Bluman, Rowland, and Mockensturm² used an opposite approach to attempt to force the successful completion of homework. Their iterative homework grading and resubmission method required students to submit, retrieve, and resubmit homework to correct errors until perfect. They found that adaptive grading did not improve test scores.

Flory and Hearn³ compared frequent homework with frequent quizzes and compared student attendance in lectures in electrical circuit analysis courses. They show little significant differences between the two methods and final exam performance. Our method differs from theirs since we have required attendance and have replaced homework with frequent quizzes.

Fisher and Shoales conducted a similar experiment in the United States Air Force Academy⁴, where course directors experimented with different methods of homework, quiz, and practical exercise or laboratory assessments. They found that student performance on homework was a

good indicator of mid-term exam results, but that student homework submissions were generally poor due to competing demands on student times.

Background on West Point and the West Point Experience

One of the main motivators for the authors to implement this course model was based on their students' time-constrained and structured environment. However, the authors feel this type of course structure can be effective and beneficial at other universities as well.

Founded on March 16, 1802, the United States Military Academy (more commonly called simply "West Point" based on its location on the Hudson River in upstate New York) is the oldest of America's service academies. West Point is also often considered to be the first college in the nation dedicated to the study of engineering⁵. Since its inception, the mission of West Point has been (with minor changes in the wording over the years):

To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country; and prepared for a career of professional excellence and service to the Nation as an officer in the United States Army⁶.

West Point has many unique features that set it apart from civilian colleges. The first is that all students are referred to as "cadets" due to their status as active-duty members of the military—specifically the United States Corps of Cadets, a special component of the United States Army. All cadets attend West Point without paying tuition and are actually paid a monthly stipend for living expenses not covered by the Academy. Upon graduation, all cadets are commissioned as Second Lieutenants in the US Army (or in a few special cases, the other branches of the US military) and are obligated to serve a minimum of five years on active duty and three years in a reserve status. Cadets also undergo periods of intense military training in the summers before each of the four academic years, and they are required to maintain the same physical fitness standards as any other soldier in the US Army. There are many other aspects that set a West Point education apart from the typical college experience, but the two that are the most pertinent to the topic at hand are the academic curriculum and the daily schedule.

The West Point Curriculum

For the vast majority of its 209-year existence, West Point had a single curriculum that conferred a general Bachelor of Science degree on all graduates. Beginning in 1985, cadets were allowed to declare an academic major that led to a specific degree. Currently there are 45 majors spanning 13 academic departments. However, every degree that West Point grants is a Bachelor of Science degree, even in traditionally Bachelor of Arts fields such as History or Philosophy. This is due to the 26-course core curriculum that all cadets must complete, as well as the requirement for all cadets who chose a non-engineering major to take a three-course core engineering sequence⁷.

Another unique feature of the West Point curriculum is the fact that cadets cannot declare a major until the fall of their sophomore year. Consequently, most cadets do not begin taking classes in their major until their sophomore spring. The effect of this situation is that most academic programs tend to be "compressed" relative to their civilian counterparts. Whereas

most colleges are able to spread the more rigorous and demanding courses out over more semesters, cadets at West Point often have semesters with three or more very demanding courses. Each cadet is required to take a minimum of five classes (15 credit hours) per semester, and many majors require several semesters of six or seven courses in order to complete all requirements. Finally, the West Point Experience is programmed to last exactly 47 months for the vast majority of cadets. There are situations where a cadet may remain at West Point for an additional semester or two, but usually these cases arise due to negative or extraordinary circumstances such as course failures, discipline problems, or medical issues. Every major at the Academy must be designed so that a cadet can complete it within the standard four-year timeframe.

A final distinctive feature of the West Point curriculum is the use of what is known as the “Thayer Method.” This is a pedagogical system named after Colonel Sylvanus Thayer, who served as Superintendent at West Point from 1817 to 1833 and is regarded as the “Father of the Military Academy.”⁸ Prior to becoming Superintendent, Thayer had extensively studied the methods in use at the L’Ecole Polytechnique in France. He then spent his tenure at West Point implementing a system that included small class size, daily recitation, frequent grading, strict discipline, and an honor code that was later formalized as: “A cadet will not lie, cheat, steal, or tolerate those who do.”⁹ This system is still largely intact at West Point, where class size is limited to a maximum of 18 cadets per section, and each cadet is expected read the lesson’s material and be prepared to discuss it before stepping into class¹⁰.

A Cadet’s Daily Schedule

To say that the daily schedule of a cadet at West Point is busy would be a gross understatement. Since West Point is a military school, one might expect a higher level of regimentation than at a civilian college. However, until one takes a detailed look at the daily activities of a West Point cadet it is impossible to fully appreciate how hectic the schedule is. A typical day in the life of a West Point cadet is shown in Table 1 below. (Note: all times are in military 24-hour format). Unlike some civilian colleges, where class attendance can be a matter of choice, cadets are required to have a valid excuse (such as a medical appointment) for each class they miss, lest they face disciplinary action that would take away some of the precious little free time they have.

Start Time	End Time	Minutes	Activity
0520	0650	90	Exercise/Personal Hygiene/Personal Time (Wakeup time may vary)
0650	0730	40	Formation and Breakfast
0730	1205	275	Morning Classes/Study
1205	1250	45	Formation and Lunch
1250	1600	250	Afternoon Classes/Study
1600	1800	120	Athletics or Military Training
1800	1930	90	Military Duties and Dinner
1930	2330	240	Evening Study Period
2330	0000	30	Personal Time
0000	0520	320	Lights out (Sleep)

Table 1: West Point Cadet Daily Schedule

From the data above, it is easy to see that a cadet’s schedule is quite packed, leaving little room for the types of personal endeavors that most college students relish. Additionally, one of the tenets of the Thayer Method is that a cadet is expected to spend two hours preparing outside of class for every hour spent in class. As Figure 1 shows, there simply are not enough hours in the day for a cadet to spend that much time on class preparation and still accomplish everything else that is a part of cadet life. This fact forces cadets to learn to prioritize their time so as to accomplish the most important tasks first while leaving others for later.

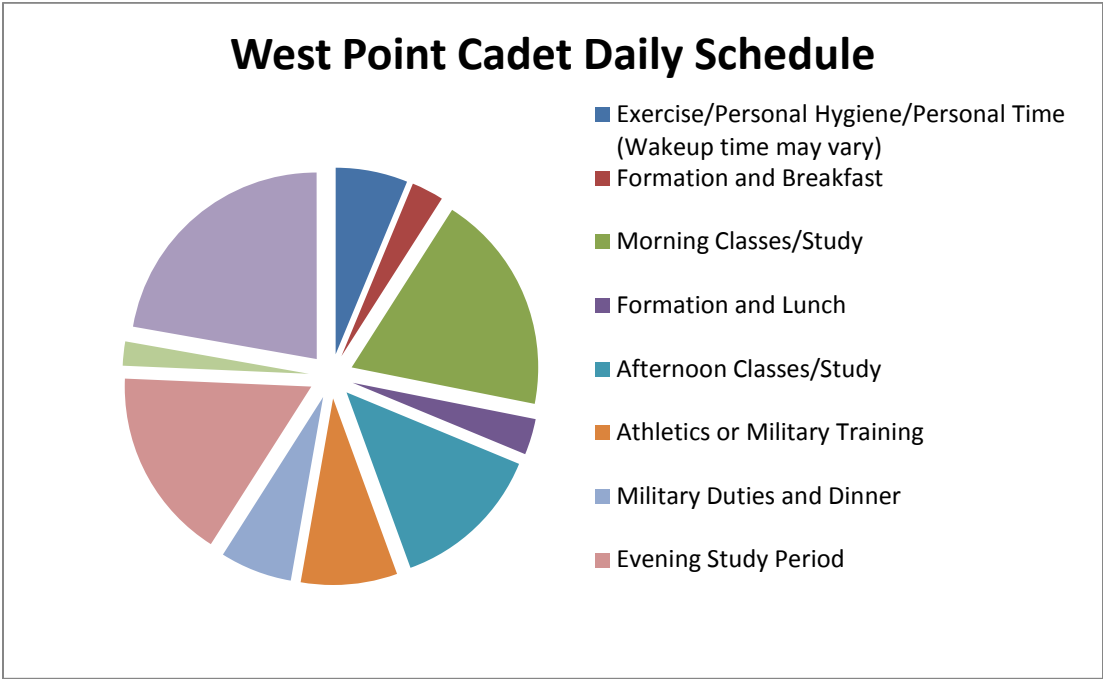


Figure 1: West Point Cadet Daily Schedule

Study Design

It is precisely because of this cadet talent for prioritization that the authors endeavored to reduce their cadets’ out of class preparation time by eliminating homework. Two of the three courses

studied here (EE301, Fundamentals of Electrical Engineering, and EE300, Fundamentals of Digital Logic) are taken by cadets who are not Electrical Engineering majors, usually in their junior or senior years. Because of their highly-developed prioritization skills, the authors found that the cadets in these courses were on average not dedicating the proper amount of time to the homework assignments, presumably because they put a higher priority on the classes in their respective majors. The third class studied (EE375, Introduction to Computer Architecture) is taken by Electrical Engineering and Computer Science majors, usually in their junior year. The overarching goals of this study, for all groups of cadets in these courses, were twofold. The first goal was to encourage the cadets to spread out their time investment and learn the material in smaller chunks, rather than trying to “cram” a large block of information right before a homework assignment was due or a test was given. The second goal was to provide the cadets (as well as their instructors) frequent and immediate feedback on their understanding of the course material.

Course	Target	Enrolled by Term			Description
		10-1	10-2	11-1	
EE300	Non-Engineers	45		37	Fundamentals of Digital Logic
EE301	Engineers	114	105	133	Fundamentals of Electrical Engineering
EE375	Majors	27	18	14	Introduction to Computer Architecture

Table 2: Electrical Engineering Courses using the Quiz Replacement Method

The first benefit that certainly every college professor or teaching assistant can appreciate is the time saved by not having to create new homework problems and grade all those homework assignments. Under our course model, graded homework is eliminated which means no more long hours in the office or at home scrutinizing students’ work. Not being tied down to this grading commitment affords the opportunity for professors and instructors to focus their attention in other important areas including individual tutoring via extended office hours, research, or more involvement in student projects or clubs such as IEEE. Some engineering educators might argue that their time spent grading homework assignments is very valuable and time well invested since the students gain from their feedback notes provided to them while correcting their work. Undoubtedly, this is true; however, can a student not check over their own work using your posted solution to suggested study problems for each lesson? Of course, students might not completely understand every solution on their own; therefore, use the time gained by not grading homework to offer extended office hours and invite students to stop by and ask any questions about the study problems they might have. Additionally, personal verbal feedback is certainly much better than the red-ink feedback written on their homework which supports better comprehension.

The next obvious advantage of this course structure is that it encourages students to adopt an adult learning model and to take more responsibility for their own learning. We provide the students with sample or study problems, usually former homework problems, that will prepare them for the quizzes and tests, but they are free to ignore the problems if they choose. Their decision on whether to work on the study problems usually boils down to their own goals, work ethic, and time management. According to Grow¹¹, these are attributes that “learners of high self-direction” have, and our job as college educators should be to facilitate their growth to this stage of learning as quickly as possible in their college careers.

With this model, we feel that a better grade evaluation for each student is achieved. Since graded homework is completed outside the classroom, students have the ability to seek assistance from other sources; whereas, in-class quizzes are solely a function of the individual. Since their performance on the in-class quizzes is largely dependent on whether or not they are studying on their own outside of class by working the study problems, the students with stronger work ethics and better time-management skills are often rewarded with higher grades; whereas those that procrastinate and try to do the bare minimum often perform poorly.

We found that the frequency of these in-class quizzes is somewhat variable. We implemented this quiz testing model using two different periods. Two courses (EE301 and EE375) use short daily 5-to-10 minute quizzes, and EE300 uses only four 20-to-25 minute quizzes. These quizzes are assigned in conjunction with other graded requirements such as preliminary laboratory assignments, full-lesson period exams, and final exams. The graded event models below visually show the placement of each graded event over the term of a semester using either the frequent daily quiz or more infrequent quiz model.

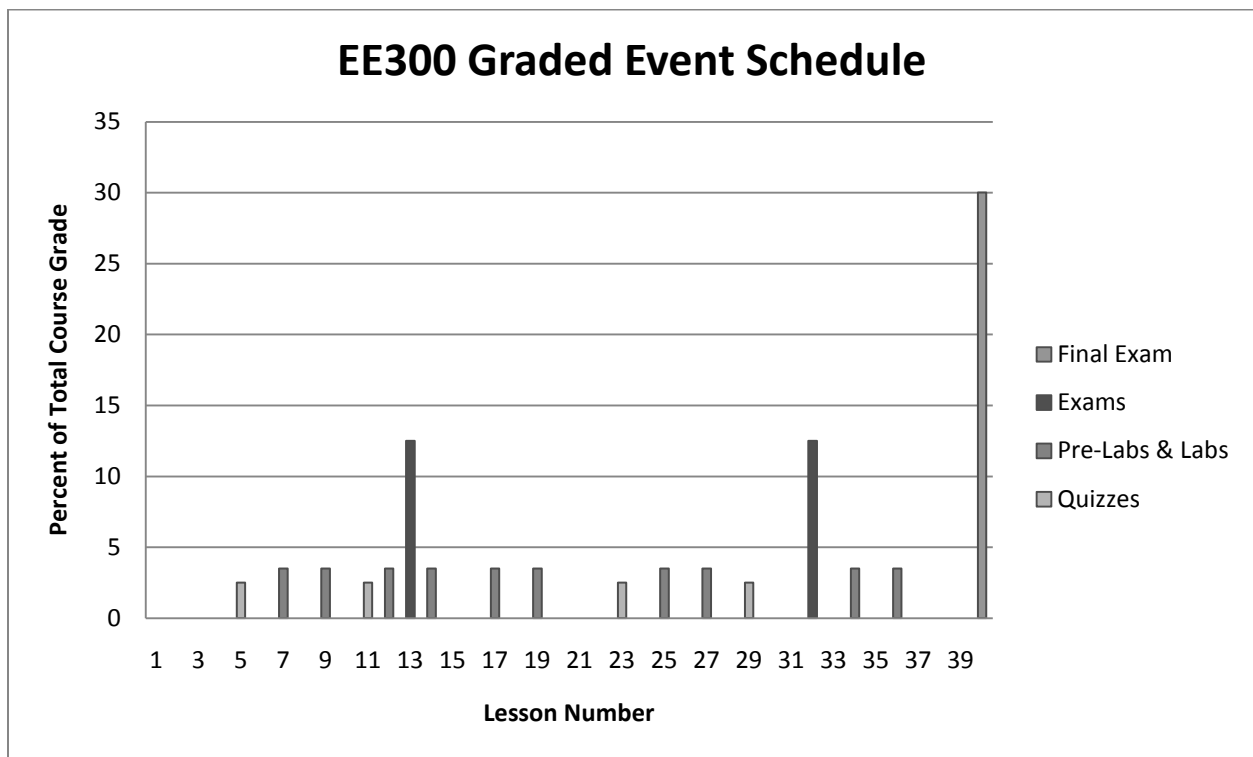


Figure 2: Graded Event Model for EE300 showing four quizzes

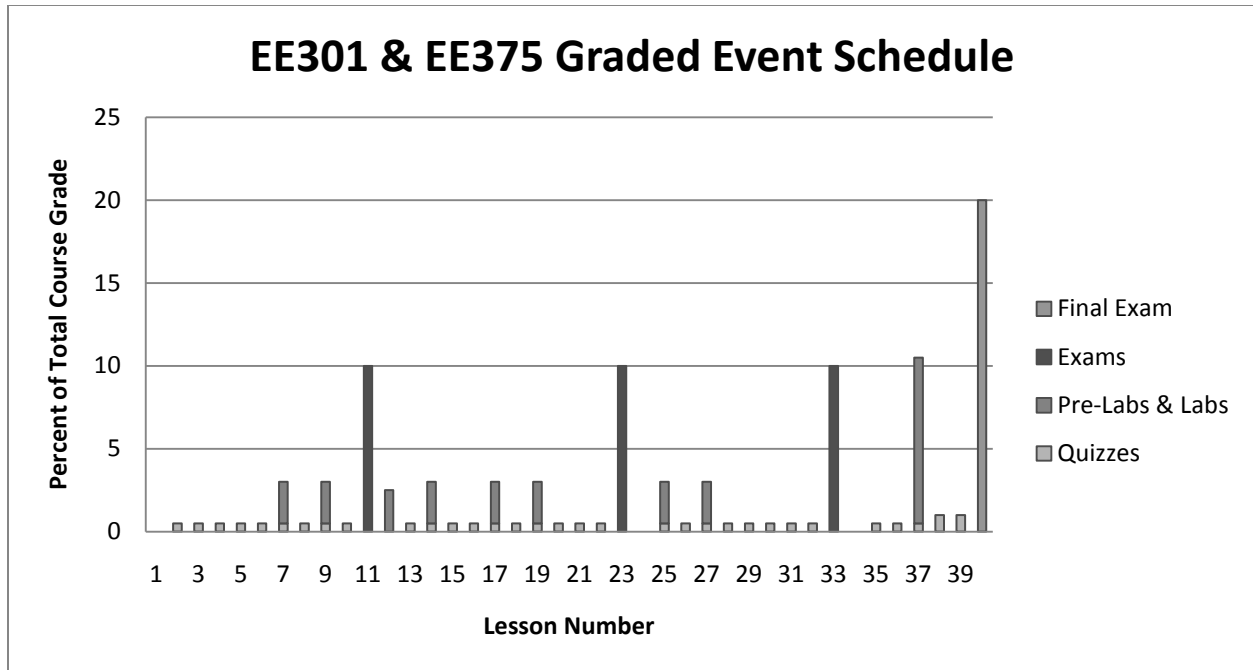


Figure 3: Graded Event Model for EE301 & EE375 showing daily quizzes

As evident in the figures above, either model provides sufficient opportunities for instructor to provide subject-related feedback to the student and evaluation opportunities for grading. In the daily quiz model, the students gain near instantaneous feedback since the students peer grade the quizzes immediately upon completion, with the help of the instructor’s quiz solution. Notice in the model with fewer quizzes that the students still get important feedback from the quizzes prior to more heavily weighted exams. According to Lowman¹², there needs to be enough evaluation points throughout the semester to properly evaluate student performance, and if properly administered, testing can be a tool used to help motivate students to learn the material and excel. Also, giving the students in-class quizzes instead of homework can actually help them perform better on the more point-heavy exams since they are under similar exam testing conditions; this could contribute to them feeling more comfortable during the longer and more heavily weighted exams, thereby helping to improve their performance.

By challenging the students with announced in-class quizzes, they are required to engage in a form of active learning. Instead of passively being lectured to for a full lesson, the students must actively engage in problem solving. Students tend to be more motivated in courses that include active learning opportunities with that supply quick feedback¹³. In either of our quiz models, there is still plenty of time available to introduce new course material after any given quiz. In the case of EE300, the quizzes are longer (approximately 20 minutes) since they are more infrequent; if the quizzes are strategically placed on lessons that can be more easily introduced, then there can still be sufficient time to cover all the new subject material.

Results

Table 3 below show the final exam results in the studied courses over a number of academic semesters. The semester where the new periodic quiz model was introduced is annotated with an asterisk.

Semester	Final Exam Results, 20% of Course Grade						Remarks
	10-1		10-2		11-1		
	M	SD	M	SD	M	SD	
Course							<i>Bold italic</i> indicates periodic quiz model
EE300 Fundamentals of Digital Logic	80.9 (n=45)	10.6			<i>84.1</i> (n=37)	<i>10.5</i>	Offered only in fall semesters
EE301 Fundamentals of Electrical Engineering	85.3 (n=114)	10.5	<i>80.8</i> (n=105)	<i>10.3</i>	<i>85.4</i> (n=133)	<i>10.2</i>	
EE375 Introduction to Computer Architecture	85.6 (n=27)	8.56	84.78 (n=18)	7.12	<i>85.14</i> (n=14)	<i>7.54</i>	

Table 3: Final Exam Mean (M) and Standard Deviation (SD) for Studied Classes

EE300 results show a marked increase in final exam performance. EE375 also showed a slight increase, but consistent with prior year's class performance. Due to course sequencing, the majority of electrical engineers take the EE375 courses in the fall semester (10-1, 11-1), and the majority of computer scientists take the course in the spring semesters (10-2). Term end assessment shows that the quiz method did not significantly change the final exam performance.

EE301 results show a decrease from the 10-1 fall term to the 10-2 term, followed by an increase into the following term. We examined course demographics and determined that due to course sequencing, most civil engineers take the course in the spring of their senior year, prior to the fundamentals of engineering exam in April, and most mechanical engineers take the course in their junior year, with a smaller set of students in other engineering discipline and exchange students spread throughout. Fall to fall semester comparisons show that student performance has not remained below the initial dip and we will compare term end results of the spring 2011 semester when they become available.

Conclusion and Future Research

Since we have shown learning is either the same or improved using this model, it only makes logical sense to replace homework with in-class quizzes based on the number of other advantages it offers. However, some may argue that there are certain challenges in implementing such a course design. For instance, by administering more quizzes in class, some may feel that valuable lecture time is being lost; however, the quizzes themselves are learning events for the students and they reinforce the knowledge the students should take away from the course. Others may fear that too many of their students will not regularly take the time to work the suggested study problems on their own. We feel that it is both necessary and beneficial to place more responsibility for the learning process onto the students, which leaves it up to them to determine their own level of success in our courses. Certainly, we strongly encourage and motivate our students to devote time to studying outside the classroom and offer our personal assistance if they encounter any problems. However, if they fail to take advantage of these opportunities, then their grade will accurately reflect their level of commitment to the course.

For future study, we plan to continue the longitudinal study with the selected courses and assess the trends on final exam grades and instructor time. Our institutional survey results of all students will be analyzed with targeted questions related to the use of cadet time, the effectiveness of the quiz method, and student preference for the method versus traditional homework assignments. Also, since all of our engineering students take the Fundamentals of Engineering Exam (FEE) in April of their senior year, we expect to compare the performance of electrical, civil, mechanical, and systems engineers on the related subsections of the FEE exam to the courses we studied to assess long-term effectiveness of the method.

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