The Benefits of Graded Homework in Math, Science, and Engineering Education

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The use of graded homework in an instructor’s pedagogy is a very effective tool to promote out of class learning, develop mature learners, and to inspire students to take initiative in developing skills for lifelong learning. Other tools exist such as quizzes, in class exams, written papers and more which all have their own advantages and disadvantages. Discussion amongst scholars has gone back and forth on whether or not students should be doing graded homework. In my own personal experiences, I have found that my performance in a subject was directly related to how much time and effort I spent outside of class. Many of the authors that have written on this topic have found this to be true for higher levels of education, but found no significant difference in grade levels below high school. In this paper, I will exam the effectiveness of homework through the perspective of several authors who have written on the topic as well as my own experiences as a cadet and instructor.

Graded Homework Promotes Out of Class Learning: Harris Cooper (1989) found that the argument for or against homework depended on the decade. He cited cases when current events changed the way America viewed education such as the launch of Sputnik. This event reversed the problem solving mentality back towards homework. He also said, “When the

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1 Harris Cooper, Synthesis of Research on Homework, November 1989, page 85.
20th century began, the mind was viewed as a muscle that could benefit from mental exercise."^2

I personally tend to forget certain math concepts when not regularly used for a long period of time. Going back to graduate school after having been away from Calculus for over 10 years was a steep learning curve. These same difficult concepts become second nature when they are executed repeatedly and frequently. This repetition of homework is something that can’t be done within the classroom environment. In my Math classes, I try to devote 25-30 minutes for the cadets to work problems at the boards. They are doing the problems for the first time after having seen a brief example or review of the reading the night before class. The in-class board problems are very effective for immediate feedback and error reduction, but the learning must continue out of class. I assign graded homeworks due on a bi-weekly basis allowing cadets time to be introduced to the material, struggle with understanding and applying it, ask questions, seek peer or instructor help, and attempt similar text problems. The fact that the cadets can choose how much time to spend on the assignment is a key factor in promoting out of class learning. Many cadets choose to wait to the last minute and miss the opportunity to seek peer or instructor feedback. They also miss the chance to ask simple questions to clarify what the problem is asking. These last minute cadets usually suffer on the grade of their assignment, but can still gain from the feedback provided.

Instructor feedback is a critical component of the homework process. Angelo and Cross (1993) referenced indecipherable comments from an instructor who eventually changed to typed feedback.^3 The effectiveness of the homework is directly dependent on the feedback and care


shown by the instructor. Answers that are marked right or wrong do not help cadets understand their mistake. Thoroughly graded homework with constructive and easily readable comments will help the student understand where they went wrong and help them learn from their mistakes. This learning from mistakes does not work for everyone. For example, cadets who put very little effort into the course don’t really care what grade they received or what comments you placed on their homework. I have observed cadets of all ability levels from F to A+ and it is readily apparent that the C and below students repeat their homework mistakes on exams. These errors are (usually) not ability based, but (are rather) due to a lack of effort. Bempechat (2004) discussed attribution theory in her article “The Motivation Benefits of Homework: A Social-Cognitive Perspective.” She stated that failure and success can be the result of effort, ability, or external factors. As an instructor, I get frustrated when making the same correction twice. The thought that comes to mind is, “Did you read the comments I put on your homework assignment?” For the most part, the C and below students are not reading the comments because they lack effort and desire to succeed as long as they pass. On the other hand, the B to A+ cadets will key in on the comments and strive to correct their performance. This level of effort is what separates their performance. Cadets who care and put in the effort easily outperform their peers of the same ability level who are not putting in the effort.

Euler’s Method, one of the major concepts taught in differential equations, is based on the idea of proceeding in the direction indicated by the slope field and making midcourse corrections for every small step taken. Homework can work in this same way for those cadets in the group who care about their performance. What is taught in class and practiced at the boards

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is often forgotten or fuzzy when cadets take the time to do the same homework problems out of class. They know the direction in which to start, but stray from the exact solution similar to Euler’s Method. Midcourse corrections are required to get back on track or change their performance to more closely resemble the exact solution. These can be in the form of in class questions, additional instruction from a peer or instructor, and eventually feedback on their performance on homework assignments. Increased feedback received improves performances as midcourse correction increases the accuracy for Euler’s Method. Again, as I have mentioned previously, feedback is only beneficial to those who wish to receive it.

**Develop Mature Learners (Leaders):**

The content of college level courses is so vast that meeting 55 minutes 40 times a semester is not sufficient to absorb all the material. Lowman makes the suggestion that an adequate time to learn all the material would require two hours spent out of class for every hour in class. This is the same model that the Dean uses at West Point. Often this is unrealistic since cadet schedules don’t allow 2 hours every night for each subject the next day. In my most recent class, I laid out a by item time budget for my underperforming sections. The syllabus afforded 18 lessons before the next exam. I told them they needed to put in 36 hours outside of class to be successful on the upcoming exam. I clearly explained how I wanted each hour spent dividing the time between homework, additional instruction, after class reflection, and so on. Two hours the night before may not be possible, but when these 36 hours are spread out over weekends and free time during the day, it becomes manageable. If the cumulative time spent out of class summed

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up to 36 then the students have met the out of class objective and should perform well on the exams.

The way in which the time is spent is a key factor in developing mature learners. Cadets who wait until the night before to begin a homework assignment are not effectively using their time and may spend 8-10 hours on an assignment that should have taken 5-6 hours. They have also missed out on the opportunity to ask questions and have their assignment proofread. The act of asking a question shows that the student has attempted the problem and wants to know how to correct a mistake or misunderstanding. This is a trait required for mature learners and future leaders. West Point does not exist solely to provide education, but to commission leaders for the Army. An officer who is willing to ask questions has a leadership trait that is essential to being successful. Often times a failed mission could have been prevented by asking a clarifying question before hand. This requires a degree of humility to let your superior know you may not have understood the guidance or intent behind the orders. This is not much different than the question asked in advance that prevents a failing homework assignment, or a great deal of time lost in the execution.

Cadets must have discipline, organization, and time management to arrive at a position to ask a question. Organization is required to balance a large class load as well as physical and military requirements. Time management is essential to avoid excessive amounts of time devoted to disproportionately towards any one subject. A strategy I often recommend is to stop studying once a road block is reached and formulate a question to be asked the following day. Some cadets will attempt to break through the road block on their own needlessly wasting countless hours that could have been saved with a two to five minute question and discussion with a peer or instructor. Not only is this time lost for this course but it has a cumulative effect
on other courses, often discouraging the student and developing a dislike, or perception of inadequacy, for the subject at hand. Discipline is the ability to choose to do the required work as opposed to falling victim to the many leisure temptations that surround cadet life. Technology and advancements in computers have placed television, games, and movies in the cadet rooms that have previously been absent in older generations. Cadets now have to make a choice to do their homework instead of watching the latest movie or sporting event. Those who learn to discipline themselves will not only become better learners, but also become better leaders.

The act of assigning homework provides an opportunity to excel not only academically, but to practice and develop the leadership characteristics mentioned above. I frequently emphasize that the math may be forgotten, or rust without use, in the long run, but the processes they went through to learn the material is what will stay with them for life. When I think back to difficult subjects, I don’t remember the small details, but I do remember what steps I took to overcome the obstacle. I remember that my writing assignments always scored better when I started early and had more than one person proofread before turning in the final assignment. The fact that you cannot always spot all of your own mistakes is acknowledging human flaws and taking steps to correct them. I also remember the more practice problems I did out of class, the higher my exam performance was. To illustrate this fact early in the semester, I made a correlation between homework and the first exam scores. I found that there was an 82% positive correlation between performance on homework and the first exam.
I used this in class as a motivational tool to encourage those cadets lagging behind that hard work will pay off. A mature learner will be successful academically and in life by internalizing this concept.

**Developing Skills for Lifelong Learning:** Lowman also states, “Recall and recognition of specific information most often results from solitary reading and concentration.” The ability to continue to learn after college is vital to staying current in today’s society. There will not always be an instructor giving homework assignments and providing feedback. In a corporation, the only feedback you may get is “Your Fired.” In the Army, this could equate to bad ratings, given jobs (assignments) with minimal responsibility, or punitive measures depending on severity of mistakes. For cadets, academic performance is practice for what they are required to do after graduation. If they fail to turn in homework, they will get a bad score. If

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they learn from this experience, grow, and change then the practice is paying off. The lifelong
learning objective is that failure to meet a submission deadline could mean losing your job or the
death of soldiers in combat.

Challenging homework assignments and a large class load teaches stress management. Often
times a surge of assignments and exams will occur all in one week. Cadets who learn to cope
with this stress will perform better under pressure. There is also the stress of the due date. A
commitment to meet a deadline can force decisions that will support achieving this objective.
I encourage cadets to communicate failure to meet the deadline when they know they are
overwhelmed or external circumstances prevented them from completing a requirement. This is the
same professional courtesy that will be required when they can’t meet a deadline in the Army. Once
again this learning opportunity is an added benefit to assigning a graded homework.

An additional lifelong learning skill is the freedom to choose if, when, and how to complete an
assignment. This is one of the advantages that Cooper outlines in his paper.7 He goes on to explain
that homework promotes independent and responsible character traits. Some of the disadvantages
he mentions are the loss of leisure time, less time for community activities, loss of sleep, promotion
of cheating or copying, and excessive help that goes beyond tutoring. Each of these negative
effects can also contain a lifelong learning objective. For example, the student who never copies
will probably get caught the one time he decides to cheat. This student will feel guilt and
embarrassment knowing his actions were wrong. He will later reference this experience when
confronted with an opportunity to cheat later on in life. I think many of us had

7 Harris Cooper, Synthesis of Research on Homework, November 1989, page 86.
a mother that wouldn’t let us watch our favorite television program until our homework was complete. A mature learner will incorporate this concept as an adult and impose the same restrictions to accomplish a required task. The cadet who relies on excessive tutoring and help to simply complete the assignment, but never really learn the concepts, will fail when they take an exam. This person should make the connection that they are responsible for their own learning and can’t rely so heavily on others.

**Conclusion**

I think that the use of graded homework offers cadets an opportunity to excel academically, internalize strong work ethics, develop initiative, time management, and self discipline. Some groups of cadets will benefit more than others as mentioned with the difference between the C and below vs. B to A+ cadets. Despite this difference, the lower group will learn that waiting to the last minute doesn’t pay dividends. Once they internalize this, they will devise alternate approaches and change their habits. If this positive effect occurs, than the graded homework has served a useful developmental purpose for the cadets. The feedback mechanisms need to be in place as catalysts to ensure the process is working. Without proper feedback, cadets will continue to make the same mistakes and never improve their performance. Strong, constructive feedback may be time consuming for instructors, but should be accepted as his/her responsibility. Good instructors who care about the learning of their cadets will spend a good deal of time grading and offering constructive feedback. At the same time, the cadets who spend time reading the feedback and acting upon it are gaining maximum benefit from the assignment. The benefits of graded homework vs. quizzes is an interesting comparison, not thoroughly discussed in these articles, that warrants further investigation. In my experience, quizzes promote more of an ability based assessment and do not provide as many feedback opportunities
as homeworks. Cadets are more likely to ask questions and seek additional instruction when
given an assignment and sufficient time to work on problems. More frequent midcourse
corrections help to eliminate misunderstandings and common mistakes. These same things can
be accomplished with a quiz, but usually occur after the grade has been assigned, as such, this
technique often discourages or disheartens students who require repetition in understanding.
Homework assignments can be turned in early or pre screened by the instructor to guide the
cadets in the right direction and fix errors in a non-punitive environment, again this tool is often
lost with taking a quiz, unless the instructor allows the student to fix the quiz for some form of
credit. This by no means should be the sole assessment tool for learning. Exams, projects, and
presentations also serve their own purpose and accomplish separate objectives. But overall,
graded homework is one of the best tools to facilitate and promote out of class learning, develop
mature learners, and to inspire students to take initiative in developing skills for lifelong
learning.
Annotated Bibliography

1) Harris Cooper, Synthesis of Research on Homework, November 1989. This article focused heavily on previous studies of the effectiveness of homework on various grade levels. The author found no significant difference among those who were given homework and those who weren’t in grade school level students. He did find a significant difference as the grade level increased. High School students showed the largest difference mainly due to the increase of course work and difficulty of the subject. This was also an excellent source for laying out the pros and cons of homework.

2) Angelo, TA., & Cross P.K. (1993) Classroom assessment techniques: A handbook for college teachers, 2nd ed. San Francisco: Jossey-Bass. This text covered many forms of classroom assessment techniques and tools. There was only a very small section devoted to homeworks in which the author focused on the usefulness derived from the instructor feedback.

3) Bempechat, Janine(2004) ‘The Motivational Benefits of Homework: A Social-Cognitive Perspective’, Theory Into Practice, 43: 3, 189-196. This article focused on the instructor’s role and reaction to homework. She explained the difference of pity vs. anger at poor grades. Anger which communicates the student didn’t try hard enough. Pity communicates a lack of ability and causes students to adopt an attitude of why try if I am not capable.

4) Lowman, Joseph, Mastering The Techniques of Teaching, Second Edition, 1995. Lowman book cover all subjects related to good teaching. Many of these aspects carry over to the instructor’s role in homework such as providing good feedback, assigning challenging yet doable assignments, and caring about the learning of your students. He mentions that homework should have a clearly defined purpose usually found in the instructors teaching philosophy.

5) MAJ Curtis A. Carver, MAJ Richard A. Howard, and COL William D. Lane Department of Electrical Engineering and Computer Science United States Military Academy West Point, NY 10996, SIGCSE ’96
This article focused on several techniques to improve the learning process for sections that have weak students who tend to hold back their peers. They analyzed the problem of weak students doing no preparation for class and cramming before any graded event. The amount of material available on the course web site in various forms only benefitted the average to best students which I categorized as the B to A+ group who care. Their problem lies with the C and below students who care very little other than doing to bare minimum to pass.

6) Jackson F. Lee Jr. and K. Wayne Pruitt, Homework Assignments: Classroom Games or Teaching Tools?, The Clearing House, Vol. 53, No 1 (Sep., 1979), pp. 31-35. This article focused more on the disadvantages of homework which can show a false sense of academic progress. The authors also examined different populations that may be able to learn without the use of homework assignments.

7) Alfie Kohn, Abusing Research: The Study of Homework and Other Examples, The Phi Delta Kappan, Vol. 88, No. 1 (Sep., 2006), pp. 8-22. This article examined certain research or the abuse there of which pointed to the same findings in the Cooper article that homework has no correlation with academic performance in lower grade levels. He also points out that at these lower grade levels, homework may cause students to miss social and community activities that are more useful at that age for development.