The Use of Extra Credit to Improve Course Design

Thomas Shepard
University of Minnesota

Abstract: This paper discusses the use of extra credit assignments in a semester-long introductory fluid mechanics course. During two semesters students (n = 180) had a chance to improve their grade by applying material learned in class to homework-type problems on topics for which time did not allow in-depth coverage. The problems were designed to expose students to the potential use of course material to real world applications while also incorporating critical math skills, yet these problems were much more challenging than an average homework problem. Half of the students took advantage of the extra credit increasing their grades by an average of 1.51%. Of the students who attempted the extra credit, 44% increased their letter grade for the course. The results show little difference in grade distribution between the students who chose to attempt the extra credit problems and those who did not, revealing that all types of students potentially can benefit from such assignments. This paper further discusses some of the more subtle benefits provided and how the manner in which extra credit opportunities are provided may improve course design.

Introduction

The topic of including extra credit in a course may invoke vigorous debate, with valid points on either side. Those opposed to offering extra credit cite arguments such as grade inflation, excess time planning and grading for the instructor, perceived fairness in when or to whom it is offered, lowering of academic standards, and a belief that during a semester a student has ample opportunity to achieve the grade they truly deserve. A further contention is that extra credit assignments can induce a moral hazard (Wilson, 2002). In this situation the fear is that by offering students extra credit they perceive less risk in performing poorly and will not study as thoroughly, as they will have the option to make points up in the future. The proponents of extra credit tout its ability to give students a second chance, rectify an exam which may have been too difficult, or explore topics in further detail than scheduled time may allow.

One gets the sense that many of the arguments against the use of extra credit pertain to the specific method in which it was provided. If this is true, judging all extra credit negatively would be akin to concluding that all the "Star Wars" movies are poorly done after only seeing "Star Wars: Episode I – The Phantom Menace". The manner in which extra credit is given is certainly tied to its merit as a tool in higher education. When used appropriately extra credit can be a versatile tool whether the goal is to introduce students to situations they will encounter in the workplace (Reid & Gwinn, 1997), increase lecture attendance (Wilder, Flood & Stromses, 2001), or make a connection between students and course material (Bicouvaris, 2000), just to name a few uses.

In this paper the use of extra credit assignments in a mechanical engineering fluid mechanics course is examined.

Project Description

The motivation for implementing extra credit assignments in this particular case arose from the desire to pace the class according to student learning. Specifically, the topic of solutions to the Navier-Stokes equation caused the students significant difficulty, resulting in a couple extra lectures reviewing calculus as it pertained to exact solutions. Due to this set-back, there was less class time to devote to pipe flows and drag, topics which are central to this subject and allow students to use many of the analytical skills developed throughout the course. This happened both in the fall and spring semester and the primary goal behind giving the optional extra credit problems was to allow students to see how the material they had been learning can be applied to real-world application problems. The extra credit was not listed on the syllabus but was announced to the entire class in the last few weeks of the semester and students were not required to complete all of the problems, but could receive credit for any partially solved problems. The potential maximum increase to a student's grade was 3.5%.

The problems were relatively challenging, required multiple steps, and forced students to use material learned in past courses (Statics and Dynamics, Thermodynamics), as well as relatively involved math. To make the problems seem less intimidating they were broken down into steps. Whereas a typical textbook homework problem is contrived to allow students to get practice doing a simple engineering analysis and help them learn the material, these problems were designed to allow students to see just how powerful all the tools we've given them are when combined. Even if time had allowed, presenting problems of this difficulty in class would be challenging. Because of the length of the problem many students' attention would wander and because of the difficulty some students may struggle to follow along even if their attentions were focused. All problems used can be found in the Appendix and it is noteworthy to mention that the extra credit assignment consisted of a single pipe flow problem and a single drag/lift problem each semester. The problems given to the second semester were on the same subjects but were new problems.

Results

Over both semesters a total of 180 students had the opportunity to do the extra credit problems and 50% of them took advantage. Interestingly, there was no significant difference grade-wise between the population of students who did the extra credit and the population that did not as demonstrated in Table 1. This result is opposed to the trend found in the literature which suggests that extra credit is predominately taken advantage of by the more gifted students in a class (Hardy, 2002; Moore, 2005). These cited works dealt with students in introductory biology and psychology courses making it possible that the difference is due to field of study, year in school, or whether the students were majors in the field or not.

	Average Grade (%)	Grade Standard Deviation (%)
Did Extra Credit	84	7
Did Not Do Extra Credit	83	9

Table 1. Grade performance of student populations

The students who did extra credit problems on average increased their grade 1.51%. This would amount to a cumulative grade increase of 0.76% for the classes suggesting minimal grade inflation. The class was graded on the plus/minus system (A, A-, B+, B, B-, ….) and 44.4% of the students who did the extra credit saw a single step increase (i.e. B to B+) in their letter grade suggesting that this option was attractive to students near a grade transition. The course was not graded on a curve and students could calculate their current grade at any point during the class which would have allowed them to know if they were borderline grade-wise. In general the students who were performing better in the class also performed better on the extra credit as shown in Figure 1.

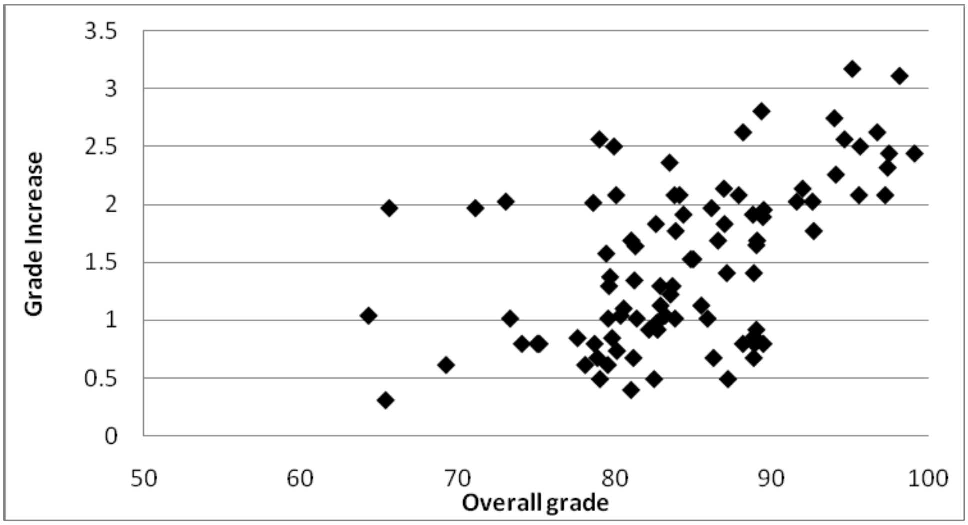


Figure 1. Distribution of extra credit performance vs. overall performance

Discussion

The administration of these extra credit assignments was well received by the students with a surprisingly large number taking advantage. The entire spectrum of abilities (D students to A students) participated and got to work with realistic problems that integrated skills learned throughout their engineering education, not just one chapter. The commonly stated downsides of extra credit were largely avoided with the main disadvantage relating to the time required by the instructor to create and grade the assignments.

Even the issue of raising a moral hazard was avoided by announcing the extra credit late in the class. If the same class were repeatedly taught by the same instructor it is anticipated that even if extra credit weren't listed on the syllabus word would spread and students would expect the extra credit to come at the end. This may create an apparent catch-22 where-in students possibly expect an extra credit assignment to be available to help them bolster their grade, and hence not give their full effort up front, whether extra credit will be offered or not. There may be some ways to mitigate this. First, have the total weight of the extra credit minimal; 5% of the total grade or less has been recommended (Palladino, Hill, & Norcross, 1999). Secondly, distribute the extra credit problems throughout the class, as opposed to having them all at the end. By diminishing the amount of extra points possible as the term progresses one might also diminish the moral hazard faced by the students while retaining most of the advantages of the extra credit problems. The challenge with this point would be in coming up with appropriately realistic problems early in the course, though one could have the students revisit material from a prerequisite course as it pertains to the pertinent subject. Finally, be up front with the students about the reasons behind the extra credit and how they will need to be quite comfortable with the material to do well on it. If they understand that the extra credit is not intended as an opportunity to make up missed points, but is aimed at exploring the applications of skills learned they may be less inclined to use it for the former.

Providing students these extra credit assignments also provided some subtle benefits from an instructor's standpoint. By getting feedback from the class and pacing it accordingly, as well as offering extra credit, the class appreciated that the instructor had compassion and was willing to consider their input. This was reflected in comments in the teaching evaluations at the end of each semester. It also minimized concerns over the class not being curved by allowing students to bolster, or insure their grade prior to the final exam. Additionally, by allowing for improved student grades one may expect improved evaluations in general as well as improved retention in a given field of study. It is important to reiterate that these grade improvements did not come at the expense of grade inflation, which may produce a similar effect but at the cost of lowering standards. Finally, developing original problems is useful if you want to contribute to a textbook. Two of these problems served as a starting point for end of chapter home work problems accepted for *Introduction to Fluid Mechanics 8th Edition* by Fox, Pritchard and McDonald.

References

Bicouvaris, M.V. (2000). Does Extra Credit Hurt Learning?, *American Teacher*, 85(2), 4.

Hardy, M.S. (2002). Extra Credit: Gifts for the Gifted?, Teaching of Psychology, 29(3). 233-236.

Moore, R. (2005). Who Does Extra-Credit Work in Introductory Science Courses?, Journal of College Science Teaching, 34(7). 12-15.

Palladino, J.J., Hill, G.W., IV, & Norcross, J.C. (1999). Using Extra Credit. In B. Perlman, L.I. McCann, & S.H. McFadden (Eds.), Lessons Learned: Practical Advice For the Teaching of Psychology (pp. 57-60). Washington, DC: American Psychological Society.

Reid, K.J., & Gwinn, S. (1997). Administration and Results of Extra Credit Projects. *American Society for Engineering Education Annual Conference & Exposition*, Milwaukee, WI: Session 1275.

Wilder, D.A., Flood, W.A., & Stromsnes, W., (2001). The Use of Random Extra Credit Quizzes to Increase Student Attendance, *Journal of Instructional Psychology*, 28(2), 117-120.

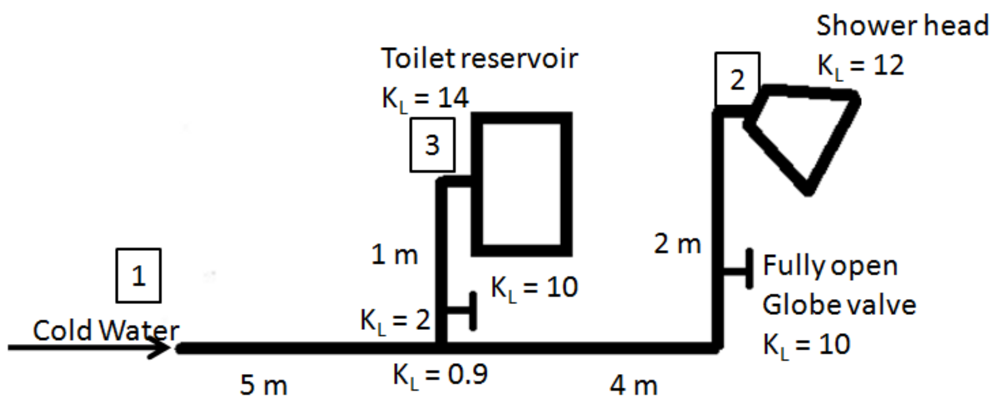
Wilson, M.L. (2002). Evidence that Extra Credit Assignments Induce Moral Hazard. *Atlantic Economic Journal*, 30, 97.

Appendix

Extra Credit Problem 1

Examine the effect of flushing the toilet on the temperature of the shower.
The temperature of the shower water is 44˚C, the cold water supply is 12˚C and the hot water heater is set to 65˚C. The plumbing of the bathroom consists of 1.5 cm diameter copper pipes with multiple connections; the cold water supply is shown below. If the gage pressure at the inlet of the system is 200 kPA during a shower and the toilet reservoir is full (no flow in that branch), determine the temperature of the shower when the toilet is flushed.

Assume that the hot water flow rate is not affected by the flushing of the toilet; assume a uniform internal energy of the water across the shower head. Use the loss coefficient of threaded connectors for the elbows (K_L=0.9).



Solution procedure:

1.Find Qcold (use the energy equation and Colebrook equation)

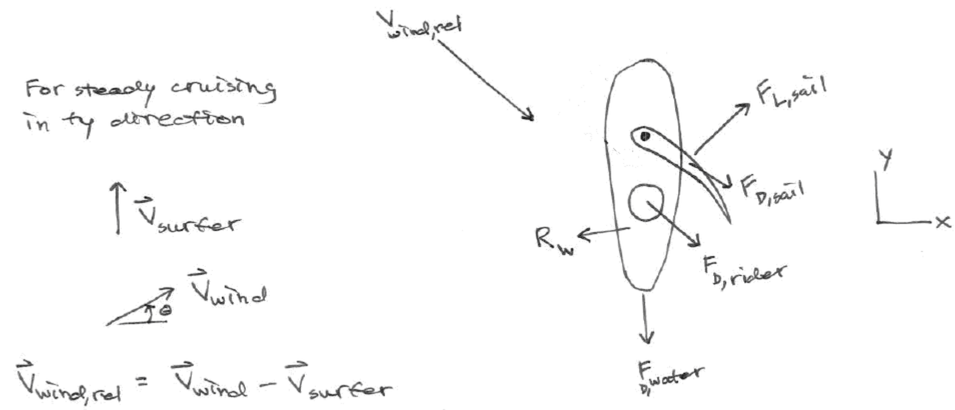
2. Knowing Qcold, do an energy balance on a CV with Qcold and Qhot entering and Qshower exiting (neglect changes in PE and KE). The continuity equation will also be needed, and maybe a Thermo text to determine internal energies or enthalpies. The goal in this part is to determine Qhot.

3. Find Qcold at the shower head when the toilet is flushed. You'll use the energy equation from 1 to 2, and from 1 to 3, the continuity equation and 3 Colebrook equations. This gives 6 equations with 6 unknowns (V1, V2, V3, f1, f2, f3).

4. Once the new Qcold is known another energy balance using the Qhot determined previously can be used to determine the new shower temperature.

Extra Credit Problem 2

The windsurfing speed record was set in saltwater on a day when the wind was blowing at 50 knots and the sailor was using a sail with an area of 4.8 m^2. The sail is like a vertical airfoil which produces lift and drag as the wind blows across it. There will also be a drag force on the sailor as well as drag due to the interaction of the board with the water. The fin of the board produces a force (R_w) in the horizontal direction so that the windsurfer is not simply blown downwind. The forward motion of the windsurfer creates an apparent wind ($V_{wind,rel}$)that is a combination of the true wind and the wind created by this forward motion. The angle of attack of the sail will be in reference to this $V_{wind,rel}$ and it is incorporating the different angles which proves challenging in this problem.



The goal is to determine how fast the windsurfer will go for a certain set of conditions. Those conditions are: V_{wind} = 50 knots, A_{sail} = 4.8 m^2, Sail aspect ratio (AR) = 3, wetted board area = 0.25 m^2, angle of V_{wind} = -15°, angle of attack of sail (α) = 2°.

Solution Procedure:

1. Conduct a force balance in the y direction.

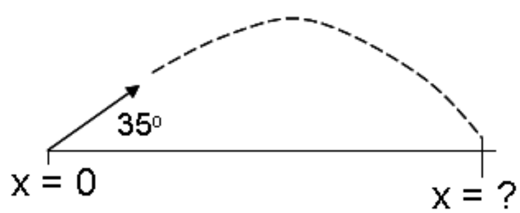
2. To determine the lift and drag on the sail assume that Figure 9.33 holds true for the sail.

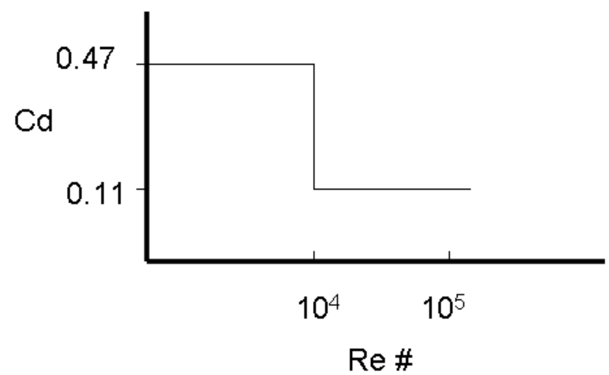
3. Determine the drag on the board. The board can be treated like a flat plate with a turbulent boundary (section 9.2.5). From this, and noting that the length scale to use in the Reynolds number for this case is the square root of the wetted board area, the drag due to friction on the board can be determined. To account for any pressure drag and wave drag incurred simply multiply the friction drag by 2.35.

*Note that Figure 9.33 and section 9.2.5 are referring to *Introduction of Fluid Mechanics, 5th Edition* by Munson, Young and Okiishi.

Extra Credit Problem 3

A baseball leaves Justin Morneau's bat at 110 mph with an angle of 35^o. Estimate how far the ball will travel before it lands. Baseball diameter = 2 7/8", Baseball mass = 0.143 kg, consider air at standard properties, and baseball drag coefficient as shown below.





a) What is the initial Reynolds number?

b) At what speed will Cd increase from 0.1 to 0.47? Do you think the ball will land before slowing down to this speed?

c) How long will the ball be in the air? Consider just the vertical component of velocity. Assuming that Cd is constant (can this be justified by part b?) determine how long it will take the ball to reach the top of its trajectory (going from V initial to V = 0). It may also be helpful to determine the height reached. Next determine how long it will take to fall from its maximum height. (assuming it lands with the same velocity it started with in the vertical direction would be incorrect).

d) Now that you know how long the ball is in the air you can determine how far it travels in the horizontal direction during this time. Consider just the horizontal component of velocity and again assume that Cd is constant (is this still justifiable?) It may be helpful to determine the magnitude of the horizontal velocity that the ball will have when it lands so that this can be used as a limit of integration. (i.e. there may be an integral from x1 to x2 and an integral from U1 to U2 involved)

e) How far would the ball travel in Denver?

Extra Credit Problem 4

Realizing that your mortgage payments would not be much higher than your current rent you recently rushed into buying a foreclosed house. Unfortunately your house is 100 years old and the water pressure is terrible on the 2^{nd} floor of the house. Below is a rough schematic of the plumbing system. After talking with some people and digging around a little bit you have determined that there are a few reasons why your water pressure is so low.

1. You house is in an old part of town with an old crudded up water main making the available pressure to your house lower than it should be.

2. Your home should really have a ¾ in. pipe coming in from the water main whereas it currently has a ½ in. pipe.

3. The pipes in your house are old and extremely crudded up by deposits over the years. This creates a large effective surface roughness and decreases the effective pipe diameter from what it should be.

Pretty much what you have on your hands is the perfect storm of plumbing issues. It may be helpful to think of the piping system as 3 sets of pipes: P1 is the piping from the water main to the house, P2a is the cold water piping that runs from the 1^{st} shut off valve (gate valve) to the branching tee that goes to the hot water heater, P2b is the cold water line that runs from this tee up to the shower head, and P3 is the piping that carries hot water.

$P_{water\_main} = 45$ psi	$D_{2a} = D_{2b} = D_3 = 0.0095$ m	let $\alpha \approx 1$
$D_{water\_main} = 0.128$ m	$\varepsilon_2 = 0.003$ m	
$\varepsilon_{water\_main} = 0.003$ m	$\varepsilon_3 = 0.006$ m	

For this problem neglect minor losses due to unions, the water meter, the hot water heater, and simply consider the first gate valve which has a contraction and elbow inside of it to be a regular gate valve. The loss coefficient for the shower head is $K_L = 12$ and the shower head can be considered to have the same diameter as D_2 or D_3.

Questions:

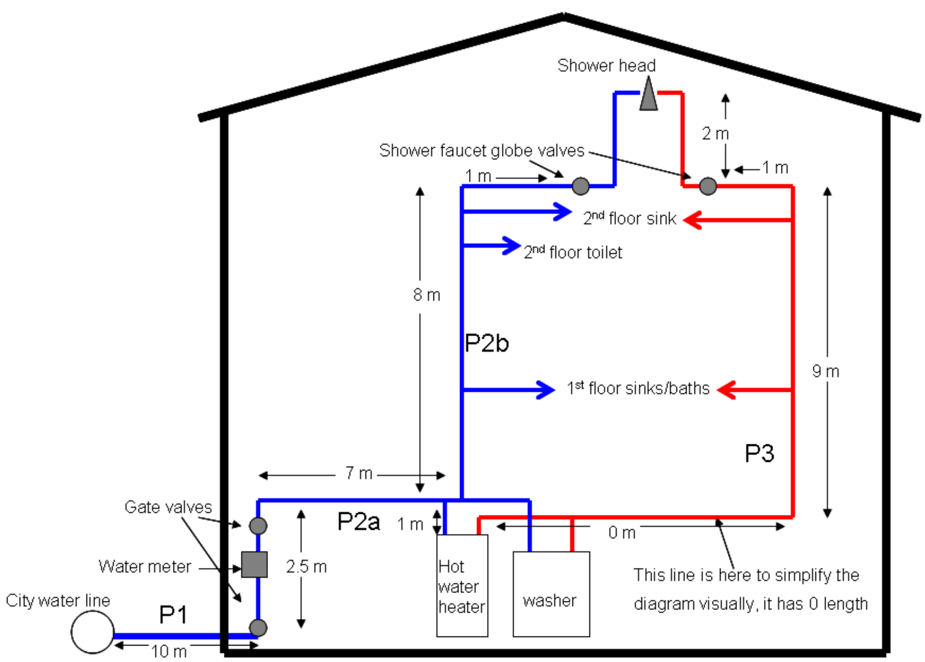
a) What will be the volume flowrate from the shower (in gallons/minute) if you turned the cold water on fully and kept the hot water turned off? Are minor losses significant? Is the velocity head significant?

b) What will be the volume flowrate from the shower (in gallons/minute) if you turned the hot water on fully and kept the cold water turned off? Are minor losses significant? Is the velocity head significant?

c) Two possible solutions to your problem that people are trying to sell you on are: 1. replacing the pipe from the water main to the house with smooth pipe with a diameter of ¾ in, 2. replacing the piping inside the house (P_{2a}, P_{2b}, P_3) with smooth piping with a diameter of ½ in. Calculate how these solutions would affect the flowrate of hot water when the cold water is shut off.

d) A final possibility would be to install a booster pump just before the branch tee to the water heater while not replacing any of the current piping. If you wanted to get a flowrate of 2.5 gallons/minute of just hot water, what pressure would the pump have to boost the system to? What would the pressure on the upstream side of the pump be? (The pump will have a low pressure on its upstream side so that the pressure drop between the water main and the pump creates the desired flowrate and it will have a high pressure on the downstream side so that the pressure drop between the pump and shower head matches this flowrate.) Is the pump idea physically possible for the desired flowrate and current pipes? What is the best flowrate you could achieve with a booster pump?

e) If replacing the pipe to the house costs $3500 while the cost to re-pipe the house (and fix all the holes in the walls created) is $6000 and a booster system costs $1000 which would you choose to fix the problem? Why?



List all assumptions used and justifications for their use.