Engineering Educators Bringing the World Together
2025 ASEE Annual Conference & Exposition
Palais des congrès de Montréal, Montréal, QC • June 22–25, 2025 ASEE
Paper ID #45372

Effects of an Optional Homework Policy on Grade Distribution in Upper-Level Mechanical Engineering Courses

Dr. Patrick M Comiskey, Milwaukee School of Engineering

Patrick Comiskey is an Assistant Professor of Mechanical Engineering at the Milwaukee School of Engineering. He received his B.S. from that institution and his Ph.D. from the University of Illinois at Chicago, both in mechanical engineering. His teaching and research interests are in the area of transport phenomena and engineering education.

Effects of an Optional Homework Policy on Grade Distribution in Upper-Level Mechanical Engineering Courses

Abstract

An optional homework policy was implemented in seven mechanical engineering courses with a total of 16 sections spanning two years and imposed upon 246 students at Milwaukee School of Engineering, a primarily undergraduate institution (PUI). The policy encouraged students to complete homework assignments not as a direct component of their grade, but rather by affording students' the ability to increase their final course grade if they simply completed all of the assignments and they were 0.5% close to the next-highest final grade. The impetus of this policy was to instill the importance of completing homework as a means to content mastery and thus improve their final course grade through their own, learner-centered motivation. To satisfy the policy, students needed to submit their good-faith work for every assignment. If students submitted their homework assignments, they were not graded, and feedback was only provided upon request. Students could judge if they were correct because the final answers were provided when the homework was assigned, and complete instructor handwritten solutions were provided after the optional due date. Over the time period this optional homework policy was implemented, 51.9% of the total number of possible assignments (2,279) were completed. As a direct result of the policy, 5.7% of students had their final course grade increased, 2.0% were not increased, and 4.5% were increased for extraneous reasons. This indicates that the final course grade for the majority of the student population (92.3%) was not affected by this optional homework policy. However, those who satisfied the optional homework policy earned an average final grade of BC whereas those students who did not submit their homework earned an average final grade of C (notwithstanding students who dropped or failed the class). This paper discusses the background of the optional homework policy, how it was implemented, results and ramifications, as well as recommendations for increasing learner-centered motivation through formative homework assessments.

Background

Homework is an integral part of education as it affords students the opportunity to practice new concepts and expand their problem-solving capabilities in a low-stakes environment. Unfortunately, the importance of homework is often not impressed upon incoming freshman as 56.7% of them report spending less than six hours per week working on homework

during their last year of high school, a behavior of which was sufficient since 97.5% had an average grade of an A or B [1]. The disconnect of earning good grades while not needing to put in meaningful work towards achieving them is a learned behavior which can harm students in higher education, and it's a difficult behavior to correct. The problem is exacerbated since assigned grades in high school are poor indicators of content knowledge because grades are awarded not just for content comprehension but also for extraneous behavior such as classroom participation, attendance, effort, etc. [2]. A critical component of content mastery in higher education is the completion of homework assignments [3, 4], but when a typical high school student enters this environment, they're unprepared for properly utilizing it as a tool.

Because of the unfamiliarity of the importance of homework for a college level education, care should be taken when designing homework assignments so that they're approachable and effective instruments of education. Towards that end, the author structures their homework assignments with the following sections, an example of which can be seen in Fig. 1:

- Relevant assignment dates
- Problem solving tips and helpful hints
- Learning objectives
- Suggested textbook reading sections
- Solved examples throughout relevant sections of the textbook
- Problems presented at the end of the textbook chapter or back of the book
- A set of custom, instructor-written problems

The first two sections simply inform students of the requisite dates for the assignment and then list common statements that may help students such as, "try to solve the problem algebraically first and only use numbers/values in the final steps of your solution when applicable", or "be sure to include units when you insert numbers". The learning objectives are aligned with the course learning outcomes and help maximize the value of the assignment because students should be informed on what they're supposed to get out of an activity [4]. Active reading is an important component of improving student metacognition [3], so suggested textbook reading sections are listed next. To successfully influence reading comprehension though, students need sufficient background knowledge [5]. This foundation is provided to students prior to them starting the homework because it's assigned after the relevant content has been discussed during the class. This methodology can help students reinforce new, complex, topics.

Homework IV: ODSSC – Extended Surfaces

Assigned: Class 12
Target Completion: Class 16
Submission By: Class 24

- Textbook examples and problems are out of the 6th edition of the class textbook.
- Try to solve the problem **algebraically** first and only use numbers/values in the final steps of your solution when applicable. Be sure to include **units** when you insert numbers.
- When solving these problems on an exam, to receive full credit, you must:
  - Sketch a figure as needed, and ensure that you clearly indicate your coordinate system (and define/align it's origin appropriately!).
  - Start your analysis from the most **basic forms of the governing equations**.
  - List all assumptions and give reasons for simplifying equations if applicable.
  - Define your boundary and/or initial conditions as needed.

Objective

- Develop an understanding for the differential equations for the temperature distribution in an extended surface.
- Identify the common boundary conditions utilized in the analysis of fins.
- Calculate performance metrics of fins and fin arrays such as the heat transfer rate, efficiency, and effectiveness.

Suggested Reading

1. Section 3.6 (sans §3.6.4)

Solved Textbook Examples

1. Example 3.9: Using the long fin approximation.
2. Example 3.10: Fin network inclusion analysis.

Textbook Problems

1. Problem 3.109: Using temperature distribution.
2. Problem 3.112: Derivation of an extended surface differential equation.
3. Problem 3.131: Analysis of a simple fin.
4. Problem 3.157: Analysis of a triangular fin.

Figure 1: The first page of a typical homework assignment. This particular example is for Heat Transfer and shows all sections of the assignment except the custom problems which are on the remaining pages of the assignment.

The final three sections are generally quantitative and consist of solved examples discussed in the textbook, direct textbook problems, and then instructor-written custom problems. Solved examples spread throughout the textbook are provided for students who need a framework for getting started on the more complex custom problems. These work samples can help students who do not know how to get started [4], but they may undermine student testing performance by providing a cognitive shortcut [3]. Because the expectations for summative assessments are regularly made clear to students and go above and beyond what's assigned as homework, however, the solved textbook problems are expected to be a net positive addition to homework assignments. Decent, end of chapter textbook problems are then listed next prior to the final section, a set of custom, instructor-written problems.

These custom homework problems were developed so students can become familiar with the tone of instructor-written questions and so that expectations on problem complexity is clearly conveyed. Constructing activities in this manner can enhance student's feelings of competence [3] which is valuable when they're preparing for summative assessments. Additionally, the problems are generally ordered in difficulty from straightforward to more complex to reduce learned helplessness [3, 6], an issue that's particularly acute because of a typical student's prior relationship with homework. Where possible, the custom questions are made realistic and relatable so that the activity is interesting, thus engaging the students [4]. Answers to the custom problems are immediately available to students when the homework is assigned, and after the suggested due date, instructor-written solutions are provided as well. Solutions to the textbook problems written by the textbook publisher are immediately provided when the homework is assigned.

Significant care has gone into the structure and content of each homework assignment so that it's approachable and students can get the most out of it. A new homework assignment is provided roughly weekly which makes grading each assignment a time-intensive task. But because homework is intended to be a formative assessment that students should use to test themselves on content comprehension [3], the author thought it'd be beneficial to make the assignments not a component of their grade. However, this may further disincentivize students from completing homework assignments which is compounded by students whose background proves there's little benefit in completing the assignments anyway. Because this is detrimental to student success in higher education though, a policy was drafted to motive students into completing the homework, even though it's not a direct component of their grade. This is termed an optional homework policy and it was designed to motivate students to complete the work and be approachable so that students benefit from this effective educational tool. This paper discusses the policy, presents results of its implementation, and then discusses outcomes and future plans.

Policy and Application

The optional homework policy was applied to each homework assignment throughout the entire term and its intent was to instill in students the importance of completion and maintain high standards of education while not overwhelming the instructor with multitudes of graded formative assessments. This was accomplished by providing students an avenue to submit their work for their solutions of the custom homework problems of each assignment approximately one week after it was assigned. The submitted work was not graded and feedback was not provided unless specifically asked for by the student. The assignments were simply checked for completion and if a student submitted their work for each homework assignment and were within 0.5% of the next higher final course grade at the end of the term, their grade was increased to the next higher level. There was no penalty for not submitting a homework assignment, but students were regularly coached throughout the class on the importance of completing the assignments. They were encouraged to work on the problems as a means of studying for the summative assessments, not just doing the work for a component of their grade. The policy was discussed in class and written in the syllabus for each course as:

> Homework will be assigned as it is an essential tool for your education. It allows you to engage with the material on your own time at your own pace to explore problem solving techniques and content application. Since homework is a formative assessment, it will not be graded and it is not mandatory to submit it via Canvas. However, you will have the opportunity to upload your solved custom homework problems to Canvas in order to justify the possibility of increasing your final course grade (see the Grading Policy section). Answers will be posted to Canvas and the problems will be illustrative of the general material and content found on the exams.

This text was a bullet point listed in a General Course Policies section of the syllabus, and the text in the Grading Policy section referenced in the quote above was written as:

> I reserve the right to increase final course grades if they are within 0.5% of the next higher grade. Your final exam and homework submitted to Canvas will be used to justify any possible upward movement.

It should be noted that while the policy stated a combination of the final examination and homework submitted were used to justify any possible increase of final course grade, in practice,

the final examination was never needed to be used as a justification for an increase. Therefore, the data discussed within the Results section herein is solely due to the homework policy.

This policy was applied to four Fluid Mechanics courses comprising 12 total sections, one Heat Transfer courses consisting of two sections, and two Aerodynamics courses consisting of one section per course. In total, it was applied to seven mechanical engineering courses consisting of 16 sections spanning two years and involved 246 students with 2,279 total possible homework assignments. The three courses are part of an undergraduate mechanical engineering track where an undergraduate mechanical engineering student would typically take Fluid Mechanics during the fall semester of their third year and Heat Transfer during the spring semester of their third year. Aerodynamics is a technical elective which is normally offered during the spring term and usually only fourth year students are enrolled in the course.

Results and Discussion

The grade weight boundaries for each class in which the homework policy was applied, with one exception, is listed in Table 1. The one class that did not use those boundaries had a slightly more forgiving upper range resulting from a different pedagogical test. This does not affect the results presented herein, however, because that class did not have any students who were close enough to a grade border for the homework policy to go into effect.

Table 1: Grade weight boundaries for the courses in which the optional homework policy was in place.

Grade	Boundary
A	100 – 92%
AB	92 – 87%
B	87 – 80%
BC	80 – 75%
C	75 – 70%
CD	70 – 65%
D	65 – 60%
F	<60%

Of the 246 students spread throughout the seven courses, the vast majority, 227 (92.3%) were not within 0.5% of the next highest final course grade boundary. If the policy was altered to be within 1% as opposed to 0.5%, then 218 (88.6%) students were not within that boundary. This indicates that there were not many students with a final course grade that is close to the next

highest grade boundary. However, as may be expected, altering the homework policy to be implemented when within 1% of the next highest final course grade does increase the potential number of students who may get their final grade increased.

For the 19 students who were within 0.5% of the next higher grade, only 14 of them had their final course grade increased. This is because the policy requires two components to go into effect. First, the student needs to be within 0.5% of the next highest final course grade boundary, and second, they need to complete and submit their work for the custom homework problems for every homework assignment. While all 19 students were within the 0.5% requirement, there was no indication that those five students whose final course grades were not increased worked on and submitted their custom homework problems. Therefore, their final course grade was simply not increased. The grade distribution for those students who were within 0.5% of the next higher final course grade can be seen in Fig. 2. The majority of students whose final course grade was increased went from a CD to a C, or a C to a BC, whereas the students who were not increased were spread throughout the spectrum of possible grades. Notwithstanding the small sample size of students who were within the next higher final course grade boundary, it's interesting to note that the those who benefited from the policy were near the middle of the grading scale.

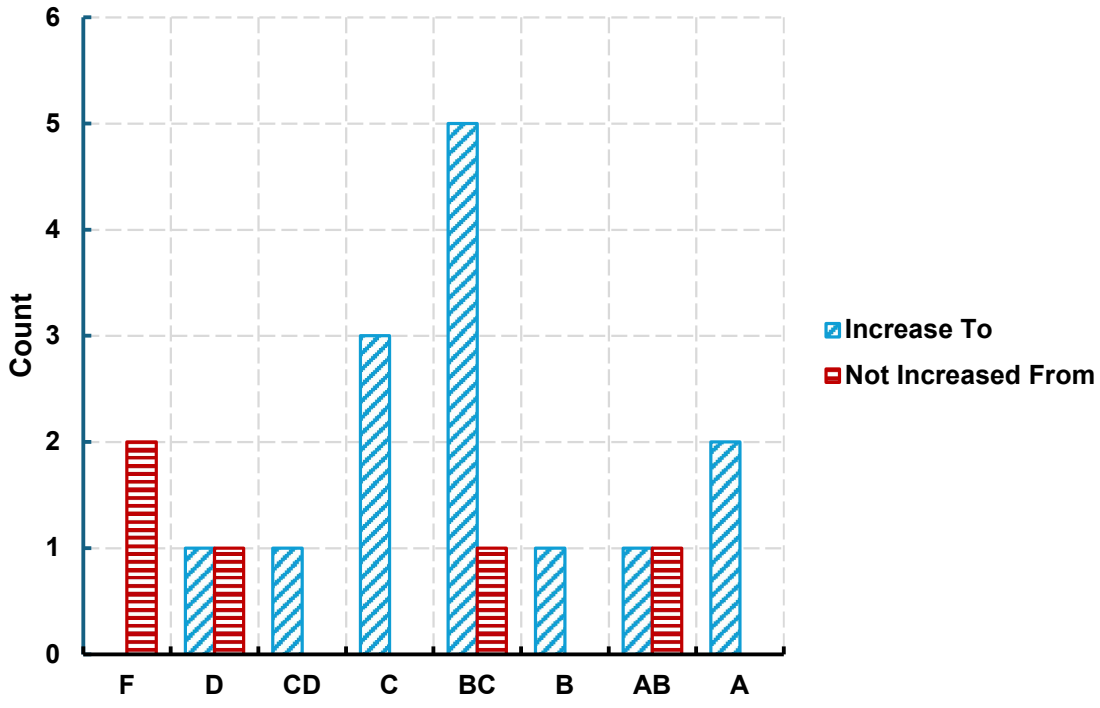

Figure 2: Final course grade distribution for students who were within 0.5% of the next higher final course grade. Blue crosshatched bars depict the 14 students whose final course grades were increased because of the homework policy and red horizontal-striped bars are for the five students whose grades did not increase.

The 19 students depicted in Fig. 2 had the opportunity of completing a total of 171 homework assignments. Contained within that group of students are those who took Aerodynamics, Heat Transfer, and Fluid Mechanics, which had nine, 12, and 12 homework assignments, respectively. The 14 students who had their final course grade increased, completed and submitted 113 out of 120 (94.2%) of the homework assignments whereas the five who were not increased, completed and submitted only eight out of 51 (15.7%) homework assignments. Therefore, contrary to the policy as discussed in the classes and outlined in each syllabus, there was leniency in the acceptable number of assignments submitted. It was deemed sufficient if nearly all assignments were completed (i.e., 94.2%), but if only 15.7% were, it was unacceptable. It was noticed for the entire cohort that homework completion was nearly bimodal. Students either completed nearly all of the homework assignments, barring a deviation of missing one or two assignments, or they didn't complete any.

To investigate the effect that completing homework assignments had on a student's final course grade, the grade distribution of all 246 students was binned into those who completed >75% of all possible assignments (110 students), and those who completed ≤75% (136 students) and shown in Fig. 3. The cutoff of 75% completion was chosen as an indicator because that differentiates students who only missed two homework assignments for the entire term. The difference between the two binned groups is striking. It should be emphasized that these are students who are only marked as having *completed* the custom homework problems, not that their homework is necessarily correct. The average final course grade (including students whose grades were increased due to the homework policy) for students who completed >75% of the possible homework assignments was a B closely followed by a BC, whereas students in the ≤75% category was a D (notwithstanding students who withdrew or failed, W or F, respectively) closely followed by a C and then CD. There is a clear distinction between students who do not complete a majority of the homework assignments not only with an average grade, but also the withdrawal and fail rate. Not a single student in the >75% category withdrew and only six failed, but 26 withdrew and 30 failed in the ≤75% category.

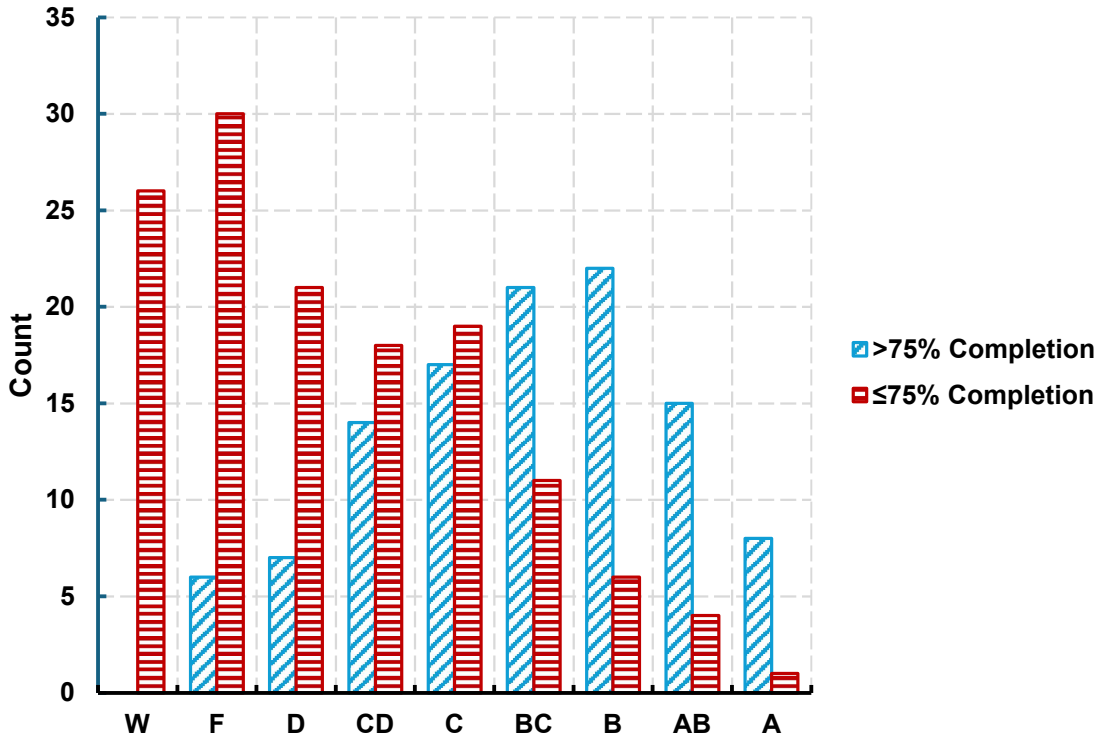

Figure 3: Final course grade distribution for all 246 students binned into two categories based on only the completion of the custom homework problems. Blue crosshatched bars depict the 110 students who completed >75%, and red horizontal-striped bars represent the 136 students who completed ≤75%.

Figure 3 should not be used to extrapolate that completing homework assignments is the sole reason student's final course grades were higher. This is particularly true because the homework assignments did not have a direct influence on final course grades except when the homework policy is in effect. However, the students in the >75% category did actively engage with the course material more since they completed the homework assignments, and it's clear that this resulted in a positive influence on their final course grade. This may be because students who are completing the homework assignments are already engaged with the course material in other ways and inherently study for summative assessments throughout the term. In other words, completing the custom problems of the homework assignments can be an indicator of an engaged student, and this student is more likely to earn a higher final course grade than a student who is not engaged with the course material.

Additionally, since the homework problems were not checked for correctness, it appears that students ensured on their own that their work, or at least the problem-solving process, is correct. Otherwise, Fig. 3 would not have such a stark difference in averages of a B compared to a D. This indicates the timeline of the homework assignments is successful where answers are

immediately provided, and then instructor-written solutions are provided after student's submit their assignments. The homework policy definitely played a role in the final course grades of the students in the >75% category, because in the grade distribution of only the 232 students who were not affected by the policy shown in Fig. 4, the average course grade is a C (notwithstanding W or F). In other words, the homework policy positively shifted the final course grades of students who were within the >75% completion category as expected. Moreover, it seems to have provided sufficient motivation just to potentially increase their grade, not directly increase it, even though only roughly half of the cohort (44.7%) completed >75% of the homework.

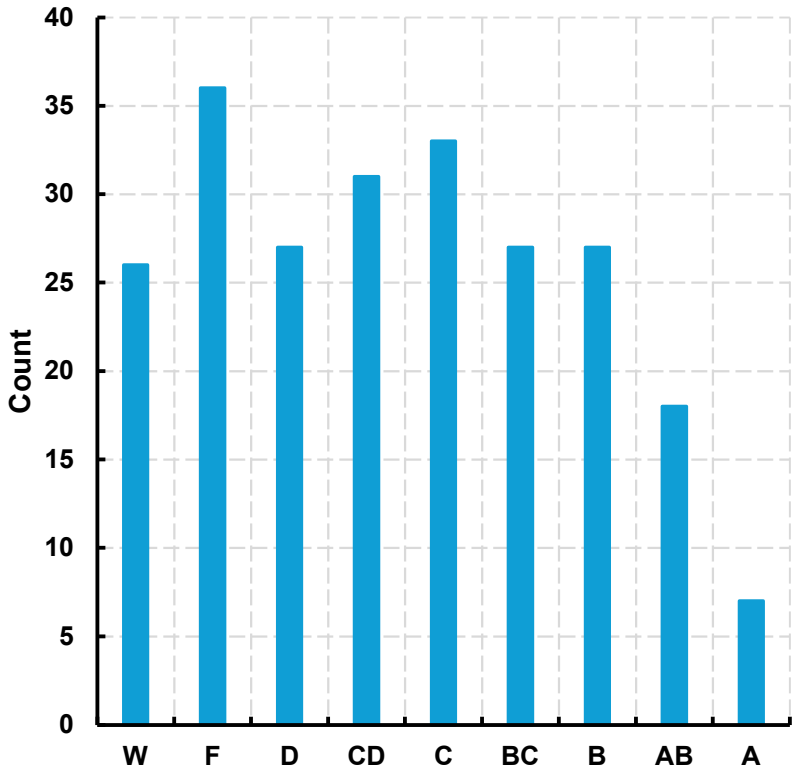

Figure 4: Final course grade distribution of the 232 students who were not affected by the optional homework policy.

For the 2,279 total number of possible homework assignments covering two years of three separate classes taken by 246 students, only 1,182 (51.9%) of the assignments were completed. A completion rate of roughly half of the assignments is certainly indicative of low participation, but it should be emphasized that this is an entirely voluntary participation. While it is possible that the incentivization of potentially increasing the final course grade is not enough, the agency it affords students to impact their own grade is sufficient justification for continuing the policy. It's hypothesized that showing a result such as Fig. 3 in class along with a discussion of the homework policy will increase participation.

The optional homework policy alone is not a sufficient assessment technique to prepare students for summative assessments since only 44.7% of the students completed >75% of the homework assignments per term. For Fluid Mechanics and Heat Transfer, students were regularly assessed for content comprehension with weekly textbook reading quizzes so that they could track their understanding as the course progressed. In Aerodynamics, this was accomplished with regularly spaced small, graded projects. If these additional graded assessments were not done, it's suspected that students would not properly grasp their understanding of the course content because they were not provided feedback on the homework assignments that were completed. In other words, this optional homework policy is part of a broader holistic approach that requires additional feedback scaffolding for students to be successful.

It's interesting to note that for every course which the policy was enacted, no students complained about the policy. The five students who were within 0.5% of the next highest grade level depicted in Fig. 2 readily accepted that they should not have their final grade increased, and students close to 0.5% but not at that level never argued that the policy should apply to them. Additionally, most students who started doing the homework assignments, continued doing them for the rest of the term. It's possible that these students are those who would be doing the homework regardless of the policy, but the policy does explicitly state that students need to complete all assignments, hopefully providing incentive to consistently engage with the material outside of class on their own.

Conclusions

A homework policy which encouraged students to complete homework not as a direct component of their grade was implemented in undergraduate Fluid Mechanics, Heat Transfer, and Aerodynamics for two years. The homework was assigned roughly weekly and consisted of a stated learning objective, suggested textbook reading sections, useful solved example problems within the textbook, book problems, and then a set of instructor-written custom problems. The assignments had a suggested completion date and then a date in which they need to be submitted by to be eligible for the homework policy to take effect. The policy afforded students the ability to have their final course grade increased if they were within 0.5% of the next higher final course grade and they submitted their work for each custom homework problem throughout the entire term. Homework was simply marked for completion, not graded. As soon as the homework was assigned, students had access to the step-by-step answers for the textbook problems, and the final

answers for the custom problems. After the suggested completion date, step-by-step instructor-written solutions were provided for the custom problems.

There was a total of 246 students for the courses in which the policy was in effect, and 19 students were within 0.5% of the next highest final course grade. Of those 19 students, only 14 had their final course grade increased because they submitted the custom homework problems for 94.2% of all possible homework assignments. The average final course grade for a student whom the policy resulted in a grade increase was a BC. To investigate the effect that completing homework had on a student's final course grades irrespective of the optional homework policy, students were binned into those who missed a maximum of two assignments per term (>75% completion) and those who missed more (≤75%). It was clear that students who simply completed the custom homework problems earned better final course grades because the average for the >75% completion group was a B, whereas it was a D for the ≤75% group (notwithstanding students who failed or withdrew). Since the custom homework problems were only checked for completeness, it seems as if students do not need direct feedback on homework to improve their grade. Simply working on and completing the work is beneficial, however, this does not indicate that the homework is the sole reason for an increase in a student's final course grade. It's possible that the students in the >75% completion group actively engaged with the course content more, on top of also completing the custom homework problems.

With such a marked increase in the final course grades of students who completed the custom homework problems without providing graded feedback, the overall structure of the optional homework policy was deemed to have a positive impact for students and faculty alike. Roughly half of all possible homework assignments were completed, even though there was only a possibility for it to alter a student's grade. On one hand, this is a large percentage of completion for an assignment which has no direct impact on a grade, but on the other, only half of the assignments completed isn't a staggering amount. Moreover, only 19 students met the criteria to be within 0.5% of a grade boundary (out of 246 total), and only 14 had their final course grades increased. To improve participation in completing homework assignments, subsequent courses in which the optional homework policy will be in effect will change the bound for considering a final course grade increase from within 0.5% to 1% of the next highest final course grade. It's hypothesized that this will minimally affect the number of students for which the policy is applicable (it would've changed the current cohort from 19 possible students to 28), but hopefully it will motivate more students to be within that >75% completion category because the policy bounds will not be as strict. Additionally, Fig. 3 is going to be shown to students when the homework policy is initially discussed to provide further motivation.

Finally, the optional homework policy provided undergraduate students a freedom that they're not typically afforded. It permits students a pathway for understanding that the onus of their education is in their own hands. This is an important lesson especially for upper-level students, because they'll soon be expected to be professional engineers who can independently work on and solve problems which inevitably involves some amount of independent learning. The potential for positive impact on students and faculty ensure that albeit some minor tweaks, the policy will be implemented again in future courses.

References

[1] E. B. Stolzenberg, M. C. Aragon, E. Romo, V. Couch, D. McLennan, M. K. Eagan and N. Kang, The American Freshman: National Norms Fall 2019, Los Angeles: Higher Education Research Institute: UCLA, 2020.

[2] A. J. Bowers, "What's In a Grade? The Multidimensional Nature of What Teacher-Assigned Grades Assess in High School," *Educational Research and Evaluation,* vol. 17, no. 3, pp. 141-159, 2011.

[3] S. Y. McGuire and S. McGuire, Teach Students How to Learn, New York: Routledge, 2015.

[4] D. T. Willingham, Outsmart Your Brain, New York City: Simon and Schuster, 2023.

[5] H. W. Catts, "Rethinking How to Promote Reading Comprehension," *American Educator,* pp. 27-33, Winter 2021-22.

[6] M. E. P. Seligman and S. F. Maier, "Failure to Escape Traumatic Shock," *Journal of Experimental Psychology,* vol. 74, no. 1, pp. 1-9, 1967.