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A Comparison of Student Learning Between Graded Homework and Suggested Problems

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Abstract

This paper examines the impact of assigning graded homework problems versus providing suggested problems on student exam performance in an introductory fluid mechanics course. Students at two different universities had specific chapters from the textbook for which graded homework was assigned and other chapters for which suggested problems were provided. Solutions to both the graded and suggested problems were provided roughly one week after they were assigned. Student performance on quiz and exam questions was then analyzed to determine if one mode of problem assignment resulted in increased learning. A weekly survey was used to determine the number of hours students applied to each problem assignment. It was found that students spent on average one extra hour on a graded homework assignment than suggested problems. Interestingly there was no significant difference in exam performance on questions which related to suggested homework problems than questions related to graded homework problems. The paper further relates these results to course design and discusses the implications for academic misconduct.

Introduction

Graded homework problem assignments have been a ubiquitous part of engineering course design and grading practices. The underlying motivation in assigning homework is a belief that students will better learn the material by working with it outside of class while solving relevant problems similar to what might be given on quizzes and tests. By working through the problems students may also pay closer attention to readings in the textbook and attend office hours in order to overcome confusion. Also, as pointed out in Fernandez, Saviz and Burmeister[1], the open setting in which homework is completed is more reflective of engineering practice than time-limited high-stakes exams. The reason for grading homework is commonly to incentivize students to give an honest effort and spend the required time to complete the assignment.

Past research does provide evidence of the positive impact that graded homework can have on learning. A review of 15 published studies on elementary and secondary students showed that in 85% of the cases, homework had a positive effect on learning in comparison to a control[2]. This study further concluded that more frequent homework and homework which is graded and receives teacher feedback also correlates with student achievement. In a similar paper that synthesized 120 publications on homework, it was found that 70% of studies found greater achievement from students who completed homework as compared to a no homework control[3], though the age of the students influenced results. Cooper[3] also concludes that homework should not be considered an area where students be tested and hence grading should be minimal. Though in order for the assignment to be taken seriously homework should be collected and have feedback provided. As discussed by Cooper[3], homework is perhaps the most complex

instructional device as it is impacted by various out-of-classroom influences beyond an instructor's control. Thus, it may be inappropriate to generalize conclusions without specific attention to academic discipline and student age which makes a strong case for continued study on the effect of homework on learning.

Specific to undergraduate engineering, some results have been reported. According to Minichiello et al.[4], engineering students and faculty both largely agree (~95%) that completing graded homework helps students learn, though having ungraded homework was not considered in the study. Further benefits of well-designed homework have been reported to include improvements in student preparation for class, out of class interactions between students and the instructor, and student motivation[5]. It is also reported[6] that students who do not have access to a solution manual on homework asked more questions of the instructor during office hours than students who could reference a solution manual. Trussell and Dietz[7] studied electrical engineering majors in a sophomore level course titled Foundations in Electrical and Computer Engineering. Their study compared student performance in two sections of the same class taught by the same instructor during the same semester. One section had graded homework while the other section assigned the same homework but did not grade it. The first semester the study was done it was found that higher test scores were correlated with graded homework, however when the study was completed in a subsequent semester there was no significant difference in test scores between the graded and ungraded groups. Aldosary[8] found that overall course grade performance correlated more strongly with homework performance than class attendance. Results from research done on four lower and upper level undergraduate engineering courses[1] concludes that homework does not correlate significantly with quiz and exam performance.

Despite its perceived benefit to the student, the available research specific to homework relating to undergraduate engineering students, minimal though it is, does not reveal consistent net positive impact on learning. The creation, collection and grading of homework assignments, as well as the numerous accompanying time-sinks (i.e. dealing with late assignments, grading deliberations, etc.), can be very time consuming for the instructor. This may ultimately detract from their ability to improve on other aspects of their courses which might be as valuable, or more so, to student learning as homework. Assigning graded homework problems also creates an opportunity for students to cheat as solutions are readily available on the internet and/or from classmates. This should be a concern for instructors as it has been reported that 74% of engineering students commit academic misconduct as an undergraduate which is second only to business majors[9]. Studies have further shown that 90-95% of engineering students use textbook solutions not distributed by the instructor[4,10]. These studies also show that 77% of engineering faculty consider solution manual use as academic misconduct whereas 84-89% of engineering students think it is not misconduct regardless of their GPA. Students overwhelmingly believe (98%) that solutions to textbook problems are useful for studying and 89% of students report that they attempt a problem before using a solution manual[5]. Though students believe that following a solution can help their understanding, research has shown that engineering students perform

better on homework and exams when they did not have solution manuals available when completing the homework[9]. Further, Passow et al. have shown that the decision to cheat or not can vary depending on the type of assessment[11] (homework vs. exam). In general terms, students are more likely to cheat on a homework assignment than on an exam. Passow et al. have also suggested that students who cheat on homework in their first years of college without consequence may develop skills to allow them to continue to cheat, and on higher-risk assessments such as tests, as they progress through school.

Certainly the issue of academic misconduct extends beyond a single course, but due to its prevalence on homework, impact on learning, and ethical implications it deserves attention in overall course design. Simply expecting students to do the ethical thing appears to not be working and thus faculty have an opportunity, and some might say responsibility, to actively reduce misconduct. Amongst engineering students, results have shown that only 21.6% agree that it is their responsibility to prevent academic dishonesty[12] and instead place the responsibility on the instructor (79.3 % agree) and institution (72.5% agree). One could simply remove the issue of cheating on homework by not having graded homework, though this must be done with careful consideration of other potential consequences.

A recent paper[13] outlines various strategies for dealing with the issue of students having access to textbook problem solutions. Each of these strategies has both pros and cons. For example, trying to use homework problems for which students cannot find a solution becomes an arms race between the instructor and the students. This may require a significant amount of time from the instructor which could be better spent improving curricula or conducting research. Transitioning away from homework and adopting a newer pedagogical strategy would also require significant effort on the part of the instructor which may or may not be beneficial in the long term. Gehringer and Peddycord[13] suggest that exams cannot assess the sum of student learning and that replacing homework grade weight by weekly quizzes may be a better alternative. While lowering the weight of homework may remove incentive to cheat, it can lead to cramming which is not good for learning. Finally, catching cheaters is typically stressful, time consuming and can create a tension between the student and instructor making it less likely for a student to reach out for help when needed. It is also likely that an instructor will not catch all of the students who are committing academic misconduct as some may simply be smarter at disguising it on their homework. In this situation students who are committing the same offense are not receiving the same penalty which simply seems unfair and unjust, though unavoidable. A more complete review on the literature relating to academic misconduct in undergraduate engineering can be found in Shepard, Anderson and Hoxie[14].

The objective of the study presented in this paper was to examine differences in time spent on problem assignments and exam performance as related to whether the provided homework problems were suggested or were to be collected and graded. The data collected for this study also allow performance on graded homework and exams to be compared. This study was undertaken at two universities in an undergraduate fluid mechanics course. The paper first

outlines the details and results for each individual university and then concludes with a discussion of their significance, instructors' thoughts of benefits not expressly quantified and potential areas of further research.

Design of Study & Results

This study was conducted in an introductory fluid mechanics course in the mechanical engineering department at two different universities. In roughly each week of the semester the students in the class were given a set of homework problems to solve. In some weeks the students were told that the homework problems were not going to be graded (i.e. suggested problems) and that solutions would be provided a week after the problems were made available to the students. In other weeks the homework was turned in to be graded and solutions were provided after the work was turned in. To incentivize students to work on the problems regardless of if they were suggested or graded, the students were told that some questions on upcoming quizzes and exams would closely match those of the suggested and/or graded homework problems.

Case 1 – University of St. Thomas

For the section of students studied at the University of St. Thomas (St. Paul, MN) 41 students were enrolled in the course. These students were mostly seniors. The class had three 65 minute lectures and a two hour lab each week. It is noted that assigned readings for the class were from *A Brief Introduction to Fluid Mechanics, 5th edition* by Young, Munson, Okiishi and Huebsch though the chapters were not covered in the order laid out in the table of contents. The suggested problems came from a mix of various textbooks and instructor written problems. The graded homework problems were newly created by the instructor for each graded homework assignment so that students could not find the solutions on the internet. The graded homework assignments counted as 10% of a student's overall course grade.

The topics covered by the suggested problems included fluid properties, Bernoulli equation, pipe flow and fluid kinematics. The topics covered by the graded homework problems included hydrostatics, dimensional analysis, drag, control volume analysis and uncertainty analysis. The assignment of a chapter to have graded or suggested problems flipped with every new chapter covered in the course. Student exam performance was assessed using two midterm exams and the final exam.

A survey was given to the students each week to document how much time they had spent on the given problem set for that week. The results of this survey are presented in Table 1. It is noted that uncertainty analysis was an assigned and graded topic for the lab component for which students were not surveyed on time spent outside of class. A comparison of the various survey results reveals that students spent on average 66 minutes longer per week working on a graded homework problem set than they did on a suggested problem set. This result is in agreement with the conclusion from a study on undergraduate mathematics students[15]. An additional survey

given after the midpoint of the semester revealed that the students would on average attempt 37.4% of the suggested problems before their solutions were posted. There were 10-12 suggested problems provided for a given week whereas graded homework assignments consisted of four problems. This suggests that the students were attempting a similar number of problems each week, but putting greater effort into the graded problems.

Table 1. Weekly time spent on homework problems outside of class

Suggested Problem Topic	Avg. Time Spent (hrs)	Standard Deviation (hrs)
Fluid Properties (chapter 1)	2.00	0.81
Bernoulli Equation (chapter 3)	1.71	0.69
Pipe Flow (chapter 8)	1.68	0.98
Fluid Kinematics (chapter 4)	1.80	0.75
Graded Problem Topic	**Avg. Time Spent (hrs)**	**Standard Deviation (hrs)**
Hydrostatics (chapter 2)	2.92	0.94
Dimensional Analysis (chapter 7)	3.00	0.94
Drag (chapter 9)	2.64	0.96
Control Volume Analysis (chapter 5)	3.03	1.22

The average student performance on exam questions related to the various homework topics is shown in Table 2. The results are given as the percent earned of the possible points for a given problem. Exam questions which involved material from multiple chapters were not considered in the analysis. While there is a lot of variation between different topics, comparing the average scores for topics covered by suggested problems with topics covered by graded problems reveals only a small difference. The average performance on suggested problem topics was 76.95% while the average performance on the graded problem topics was 77.42%. A two-sample t-test showed that this difference was not statistically significant.

Table 2. Exam performance results for suggested and graded homework problem topics (University of St. Thomas)

Suggested Problem Topic	Avg. Score (%)	Standard Deviation (%)
Fluid Properties (chapter 1)	92.86	15.58
Bernoulli Equation (chapter 3)	70.71	27.44
Bernoulli Equation (chapter 3)	79.25	20.62
Pipe Flow (chapter 8)	81.25	32.89
Fluid Kinematics (chapter 4)	60.67	25.41
Graded Problem Topic	**Avg. Score (%)**	**Standard Deviation (%)**
Hydrostatics (chapter 2)	71.67	27.93
Dimensional Analysis (chapter 7)	83.57	16.41
Drag (chapter 9)	83.21	16.19
Control Volume Analysis (chapter 5)	69.93	24.29

Uncertainty Analysis	78.70	15.65

One additional analysis is displayed in Fig. 1 which shows the relationship between performance on graded homework assignments and exam performance for the 41 students. The average exam performance takes into account both midterm exams and the final exam. The trend shows that the students who do better on homework typically do better on exams as might be expected. It is noted that the correlation coefficient for these data is 0.583, which is somewhat higher than the correlation data relating homework with exams presented by Fernandez, Saviz and Burmeister[1]. It is also noted that four of the students who averaged above 84% on graded homework showed significantly lower performance (below 59%) on exams. This is particularly troubling as a student who might turn in a near perfect homework could then show very little ability on an exam. This point is examined further in the proceeding Discussion section.

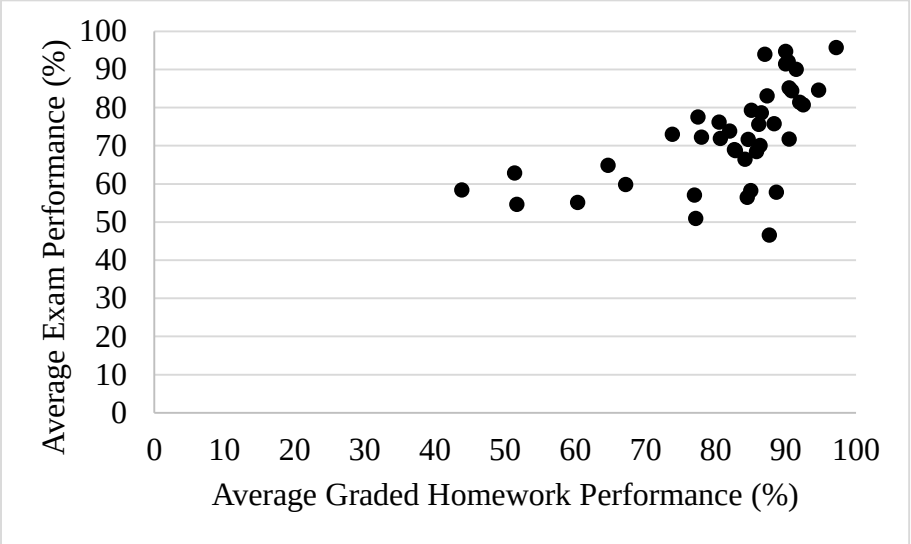

Figure 1. Relationship between grades on homework and exams (University of St. Thomas)

Case 2 –California State University, Fresno

For the section of students studied at the California State University of Fresno 24 students were enrolled in the course. These students were mostly juniors. The class had three 50 minute lectures each week. It is noted that assigned readings for the class were from *Fundamentals of Fluid Mechanics, 7th edition* by Munson, Okiishi, Huebsch, and Rothmayer and the chapters were covered in the order laid out in the table of contents. Both the suggested and graded homework problems came from the mentioned textbook. The graded homework assignments counted as 15% of a student's overall course grade.

The topics covered by the suggested problems included hydrostatics, fluid kinematics, dimensional analysis, and drag. The topics covered by the graded homework problems included fluid properties, Bernoulli equation, control volume analysis, differential analysis, and pipe flow.

The assignment of a chapter to have graded or suggested problems flipped with every new chapter covered in the course except the chapters of control volume and differential analyses of fluid flows. Student exam performance was assessed using two midterm exams and the final exam.

The average student performance on exam questions related to the various homework topics is shown in Table 3. The results are given as the percent earned of the possible points for a given problem. Exam questions which involved material from multiple chapters were not considered in the analysis. Similar to the results from University St. Thomas, there is a lot of variation between different topics. A comparison of the average scores for topics covered by suggested problems with topics covered by graded problems reveals only a small difference. The average performance on suggested problem topics was 84.26% while the average performance on the graded problem topics was 85.87%. It is noted here that many of the topics which had suggested problems at the University of St. Thomas were covered using graded problems at Fresno State. Also, many of the topics which had graded problems at the University of St. Thomas were covered using suggested problems at Fresno State. This suggests that the lack of significant difference in student performance between topics covered by suggested or graded problems is not simply an artifact of which topics were assigned to suggested vs. graded problems.

Table 3. Exam performance results for suggested and graded homework problem topics (Fresno State)

Suggested Problem Topic	**Avg. Score (%)**	**Standard Deviation (%)**
Hydrostatics (chapter 2)	90.83	10.18
Fluid Kinematics (chapter 4)	87.50	21.24
Dimensional Analysis (chapter 7)	78.26	24.76
Drag (chapter 9)	80.45	27.30
Graded Problem Topic	**Avg. Score (%)**	**Standard Deviation (%)**
Fluid Properties (chapter 1)	81.66	28.10
Bernoulli Equation (chapter 3)	86.83	16.00
Control Volume Analysis (chapter 5)	87.00	23.00
Differential Analysis (chapter 6)	90.66	23.70
Pipe Flow (chapter 8)	83.20	17.80

One additional analysis is displayed in Fig. 2 which shows the relationship between performance on graded homework assignments and exam performance for the 24 students. The average exam performance takes into account both midterm exams and the final exam. There is virtually no apparent trend between homework performance and exam performance and the correlation coefficient for these data is 0.117. The reason for this lack of correlation is currently unclear. It is also noted that three of the students who averaged above 80% on graded homework showed significantly lower performance (below 70%) on exams. This troubling result is in agreement with the data from the University of St. Thomas. On the other hand, it has to be noted that

eleven of the students who averaged below 80% on graded homework showed significantly greater performance (above 80%) on exams.

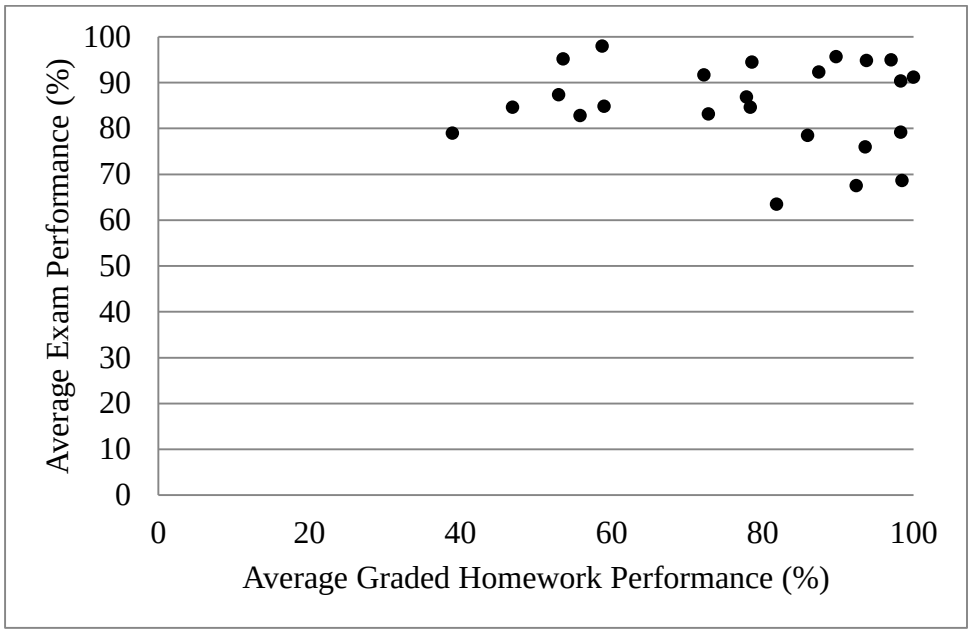

Figure 2. Relationship between grades on homework and exams (Fresno State)

Conclusions & Discussion

Conclusions - The motivation for this study was to better understand how students would respond to homework problems which were either graded or suggested. A better understanding of how problem implementation correlates to student effort and exam performance could allow an instructor to effectively tailor a course to their desired outcomes while using their resources efficiently. The quantitative and qualitative conclusions drawn should be taken with consideration of the limitations of the research methodology.

The results of this study show that grading homework promotes greater student time working on problems in a given week than simply suggesting problems. This proved to be the case both early and late in the semester. Interestingly, the graded homework problems did not correlate much more strongly with increased exam performance as compared to suggested problems. This suggests that the students learned an equivalent amount of material regardless of if problem sets were suggested or graded. Future work utilizing a more refined study might is warranted to more clearly verify an effect if present. Students did state that there was significant cramming before each exam which may have had as big, or even bigger, effect on exam performance.

Discussion - As in most classes, there are likely some students who benefit more from graded homework and some who might benefit more from suggested problems. Certainly the act of applying engineering and mathematical concepts while developing and practicing problem

solving skills is a hallmark of engineering education. Sharp students who are capable of picking up most of the course material from textbook reading and in-class examples will likely believe that they are receiving diminishing returns (i.e. wasting their time) by completing graded problem sets outside of class. For these students a few challenging suggested problems may be an ideal way to cement their understanding of a topic. Many students will admit to lacking internal motivation to work on something that is not graded and hence the graded homework serves as external motivation. It is unclear if the knowledge that suggested problems would be used on exams served to provide extrinsic motivation or not.

Though, grading homework will provide motivation for some students to perform the work diligently, it appears to also motivate academic misconduct. Results further revealed that some students who did well on homework did poorly on exams. This is possibly due to test anxiety, though the authors believe it points more towards academic misconduct. Early in the semester the University of St. Thomas instructor had to meet with some students as their homework looked almost identical. The students admitted that they had worked together and were unclear as to why this was a problem. The instructor explained how turning in identical work looks like plagiarism and helped the students identify some strategies for working together while avoiding plagiarism. It is speculated that later in the course some lower performing students copied their homework from higher performing students but in a way that would prevent it from appearing as plagiarism. As the homework problems were newly created by the instructor the students could not have found the solutions online. This deleterious peer effect on homework has also been suggested by Fernandez, Saviz and Burmeister[1].

Instructors should consider the ethical implications of assigning homework in situations where students can easily plagiarize their work. In these situations only the students who are bad at hiding their plagiarism will be punished while others might be committing the same misconduct without punishment which simply seems unfair. One might argue that the students are punished by their poor exam performance but that is misleading. Poor exam performance might be considered the punishment for not learning the material very well which is separate from being called out for academic misconduct. The engineering code of ethics clearly identifies deceptive acts, like plagiarism, as a violation[16]. This then poses an ethical question for instructors, one over which the authors are still in deliberation. If an instructor believes that students are able to easily cheat on an assignment without being caught, should the assignment be given? On the one hand it is perhaps possible that a student could cheat on any assignment, project, quiz or exam without being caught. Since instructors need to grade the students on something, and they could possibly cheat on most types of assessment, the instructor is left with little choice. On the other hand is the logic that passively accepting that academic misconduct, or any ethical violation, is happening is akin to cooperating with the misconduct. A sobering figure from a survey of 643 undergraduate engineering students at 11 institutions[9] is that only 51.2% of engineering students believe that their faculty support their institution's academic dishonesty policies. While the reader is encouraged to make up their own mind on this question, the issue of homework does

allow instructors to challenge engineering students to think and behave ethically, as we hope they will in their careers.

Based on the lack of evidence showing that graded homework improves performance over suggested problems and the ethical implications accompanying the increased likelihood of academic misconduct on graded homework, the authors agree with the sentiments of Trussell and Dietz[7]. Specifically, instructor resources dedicated to implementing graded homework as part of an undergraduate engineering course design might be redirected without a negative impact on student performance. The nebulous nature of homework will require additional research to better define the impact of grading. The limited research results available at this point suggest that instructors need not be overly worried that studies which challenge the status quo of graded homework will diminish student performance.

References

[1] Fernandez, A., Saviz, C. & Burmeister, J. (2006). Homework as an outcome assessment: Relationships between homework and test performance, *Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition*, 2006-67.

[2] Paschal, R.A., Weinstein, T. & Walberg, H.J. (1984). The Effects of Homework on Learning: A Quantitative Synthesis. *The Journal of Educational Research*, 78(2), pp. 97-104.

[3] Cooper, H. (1989). Synthesis of Research on Homework. *Educational Leadership*, 47(3), pp. 85-91.

[4] Minichiello, A.L., McNeill, L.S. & Hailey, C.E. (2012). Comparing engineering student use of solution manuals and student/faculty perceptions of academic dishonesty, *Proceedings of the 2012 American Society for Engineering Education Annual Conference & Exposition*, AC 2012-3181.

[5] Goulet, R. (2010). Individualized Homework: An effective learning strategy, *Proceedings of the 2010 American Society for Engineering Education Annual Conference & Exposition*, 2010-848.

[6] Widmann, J., Schollenberger, K. & Kennedy, J. (2007). Student use of author's textbook solution manuals: Effect on student learning of mechanics fundamentals, *Proceedings of the 2007 American Society for Engineering Education Annual Conference & Exposition*, 2007-726.

[7] Trussell, H.J. & Dietz, E.J. (2003). A study of the effect of graded homework in a preparatory math course for electrical engineers, *Journal of Engineering Education*, 92(2), pp. 141-146.

[8] Aldosary, A.S. (1995). The correlation between final grade score, attendance and homework in the performance of CED students, *European Journal of Engineering Education*, 20(4), pp. 481-486.

[9] Passow, H.J., Mayhew, M.J., Finelli, C.J., Harding, T.S. & Carpenter, D.C. (2006). Factors influencing engineering students' decisions to cheat by the type of assessment. *Research in Higher Education*, 47:6, pp. 643-684.

[10] Carpenter, D.D., Harding, T.S., Finelli, C.J., Montgomery, S.M. & Passow, H.J. (2006). Engineering student's perceptions of and attitudes towards cheating, *Journal of Engineering Education*, 95(3), pp. 181-194.

[11] Meade, J. Cheating: Is academic dishonesty par for the course?, *ASEE Prism*, 1992, 1, 30-2.

[12] Widmann, J., & Shollenberger, K. (2006). Student use of textbook solution manuals: Student and faculty perspectives in a large mechanical engineering department, *Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exposition*, 2006-756.

[13] Gehringer, E.F. & Peddycord, B.W. (2013). Teaching strategies when students have access to solution manuals, *Proceedings of the 2013 American Society for Engineering Education Annual Conference & Exposition*, 2013-6828.

[14] T.G. Shepard, M. Anderson, & Hoxie, A.B. (2014). I Did Not Anticipate This: Experiences from the Early Years, *Proceedings of the 2014 American Society for Engineering Education Annual Conference & Exposition*, Paper 9506.

[15] Cerrito, P.B. & Levi, I. (1999). An investigation of student habits in mathematics courses, College Student Journal, 33(4), pp. 584-589.

[16] NSPE Code of Ethics for Engineers, National Society of Professional Engineers. Retrieved from http://www.nspe.org/resources/ethics/code-ethics