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A Study of Students' Perceptions of Mathematics Homework Policies, with Emphasis on Engineering Undergraduates

Dr. Jennifer Vandenbussche, Southern Polytechnic State University

Jennifer Vandenbussche is an Assistant Professor of Mathematics at Southern Polytechnic State University. In addition to her research in the scholarship of teaching and learning, she does mathematics research in in the area of combinatorics, especially extremal graph theory. Her primary interest lies in coloring and matching problems in graphs.

Dr. William George Griffiths IV, Southern Polytechnic State University

William Griffiths is an Associate Professor of Mathematics at Southern Polytechnic State University. His research interests include enumerative combinatorics, permutation pattern avoidance, and the scholarship of teaching and learning.

Dr. Christina R Scherrer, Southern Polytechnic State University

Christina Scherrer is an Associate Professor of industrial engineering technology at Southern Polytechnic State University. Her research interests are in the application of operations research and economic decision analysis to the public sector and in assessing education innovation. She teaches primarily statistics and logistics courses, at both the undergraduate and graduate level. She received her Ph.D. in industrial engineering from the Georgia Institute of Technology.

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Abstract

Since entry-level mathematics courses often pose a significant challenge to the successful completion of a degree in engineering and engineering technology, encouraging student success in these courses is essential. One common cause for failure in gateway mathematics courses is a lack of homework completion by the students. In this paper, we try to determine some key factors that prevent students from completing their mathematics homework, and what policies are effective in encouraging a high completion rate. We present results of a survey of more than 600 undergraduate engineering and engineering technology students. The results of the survey can serve as a guide to inform future research into best practices in this important area.

Introduction

Since entry-level mathematics courses often pose a significant challenge to the successful completion of a degree in engineering and engineering technology, encouraging student success in these courses is essential. One common cause for failure in gateway mathematics courses is a lack of homework completion. The 2011 National Survey of Student Engagement[14] involving 683 U.S. and 68 Canadian institutions indicated that full-time seniors report spending an average of 15 hours per week preparing for their classes. Average preparation time was higher for engineering students (19 hours), but still well short of the typical guideline of 2-3 hours out of class for every hour spent in class.

Knowing how essential homework is to success in their courses, mathematics instructors use a variety of approaches to encourage students to complete the necessary practice. Unfortunately, there is little rigorous research to guide a mathematics instructor toward implementing policies that achieve this goal most effectively, and no research that we are aware of that presents ideas targeted toward Engineering and Engineering Technology (E/ET) students. The only well-studied aspect of homework policy is the comparison of outcomes in courses using online homework versus traditional homework. There are many studies comparing these two delivery methods at varying levels[1,4,5,6,8,11,12,19]. Most studies conclude that web-based homework is superior to (or at least not inferior to) traditional homework in terms of homework completion and student outcomes.

Aside from studies of online homework, however, there are very few other studies investigating the effect of various mathematics course policies on homework completion and student success. The most recent study in this area[7] compared the effect of weekly collected assignments versus weekly quizzes in a Calculus I course. There was no statistically significant difference in performance between the two groups, although the authors did report some interesting survey results. Boelkins and Pfaff[3] report on the effect of providing students with a daily schedule of tasks to complete in their Calculus III and Calculus IV courses. Rather than hand out a syllabus listing all homework problems to be completed before the next exam and leaving the students to divide the workload, the instructors explicitly broke down the tasks to be completed each day. The authors reported very favorable outcomes for their students on the departmental final exam, but no controlled study was done.

Johnson[9] compares four different treatments in a College Algebra course. All students were given the same homework assignment, but only one group of students had it collected. A second group was given biweekly quizzes, while a third was given four exams throughout the semester. The fourth group did none of these. Surprisingly, there was no difference in student performance – the only reported difference was in attrition, which was lower for the group with homework collected. Weems[18] compared two groups of students in a developmental mathematics course. Both groups were given the same homework assignment, but only one group turned it in. The group whose homework was collected received significantly more A's than the other group.

Some studies in problem-based engineering courses may have relevance to homework policies in mathematics courses. A recent study by Bennett et al.[2] involves the offering of an early homework completion bonus in a course entitled Physics for Engineers. Students were given a 10% bonus for turning their homework assignment in 24 hours before the deadline. The authors report an increase in homework averages amongst students at all achievement levels when compared with the averages of the students who took the course two years prior under a non-bonus system, although no data regarding the amount of homework completed is given. Marchetta et. al.[13] study the effect of informing students that questions on the final exam will come from homework questions. Their study looked only at final exam performance, however, and drew no statistically significant conclusions. Kaw and Yalcin[10] found that grading one problem (out of three assigned) per class in a Numerical Methods course for mechanical engineers had no positive effect on final exam performance when compared with assigning but not grading homework.

There are other homework studies from outside mathematics and engineering (see for example Peters et al.[15] and Ryan and Hemmes[16]), but the problems-oriented nature of introductory mathematics courses would seem to limit the relevance of such studies. Clearly significantly more work is needed in the area of mathematics if the mathematics community is to make informed decisions about course policies.

The goal of the research presented in this paper was to a take a small step toward filling this gap. Over 600 E/ET students were surveyed in order to understand what key factors they perceive as preventing them from completing their mathematics homework, and what policies are effective in encouraging a high completion rate. Although we acknowledge that the students' perspective may not always reflect reality, we do believe that the results provide a guide to inform future research in the area.

Methods

Approximately halfway through fall semester 2011, we surveyed undergraduates at our university in mathematics courses ranging from College Algebra to Calculus III, asking them questions about their homework completion habits and what their instructors could do to encourage more homework completion. (The survey is available from the authors upon request.) We received more than 1,000 useable responses. Of these, 59.9% were from engineering or engineering technology majors. Southern Polytechnic State University (SPSU) is a special-purpose institution in the University System of Georgia with over 5000 students enrolled. Approximately 80 percent of the student body is male, and many of the students are nontraditional. The school's mission is to offer both traditional and nontraditional students bachelors and masters degrees and continuing professional development in the sciences, engineering, engineering technology, applied liberal arts, business, and professional programs. A large majority of students major in STEM (science, technology, engineering, and mathematics) fields.

Table 1: Self-reported demographics for engineering and engineering technology majors. (n=610)

Course	
Lower level courses	29.6%
College Algebra	13.8%
Precalculus	10.4%
Probability and Statistics	5.4%
Intermediate level courses	69.9%
Calculus I	21.8%
Calculus II	29.7%
Calculus III	5.4%
Ordinary Differential Eqns	9.8%
Discrete Math	1.4%
Linear Algebra	1.8%
Gender	
Male	94.0%
Female	6.0%
Race/ethnicity	
White	63.1%
African American	10.0%
Hispanic	7.5%
Asian	5.9%
Other	4.4%
How many hours per week do you work?	
none	30.1%
1-10	16.8%
11-20	18.5%
21-30	16.0%
31-40	9.7%
more than 40	8.9%
Which best describes your status last year?	
High school student	25.4%
College student	71.3%
Not a student	3.3%

As the focus of this paper is engineering and engineering technology students, their demographics are reported in Table 1, above. (Those interested in the results from the rest of the students and a comparison of responses between demographic groups and course levels are referred to the authors' other paper.[17]) Note that we divide the courses surveyed into two categories: "lower level courses" (College Algebra, Precalculus, and Probability and Statistics) and "intermediate courses" (Calculus I, Calculus II, Calculus III, Discrete Mathematics, Linear Algebra, and Ordinary Differential Equations). The enrollment in upper level mathematics courses at our institution is quite small, so we elected not to include them in the survey. All demographic information (aside from course title) is self-reported. There is a chance that some students were enrolled in more than one math course (specifically Discrete Math or Probability and Statistics with another course), but that number would be very small.

The data from all of the surveys was entered into Excel and Minitab for analysis. In addition to reporting summary statistics in the results below, we often use the mean of the Likert scale responses to make comparisons between questions and between demographics. There is some disagreement about which tests of the equivalence of sample means on results from a Likert scale are appropriate. For this reason, we chose to use the conservative Mann-Whitney U-test when comparing two groups. For comparisons among multiple groups, we used Kruskal–Wallis one-way analysis of variance by ranks. Post-hoc analysis was done with Holm's sequential Bonferroni method. Unless otherwise noted, we used a p-value of 0.05 for all claims of statistical significance below.

Results

In the first four questions, we gathered information about how students felt that homework should be administered. Full results are available in Table 2. For the format preferred, it should be noted that respondents strongly favored policies to which they were accustomed. While textbooks and worksheets are commonly used on the SPSU campus, very few instructors have used online homework thus far. (Worksheets tend to include problems very similar to those in the textbook; anecdotal responses indicated that students who prefer worksheets do so primarily because of convenience.) It is also typical among math faculty at SPSU to count homework in the 5-25% range, which was the preference of more than three quarters of the students. Ninety percent of the E/ET majors preferred that homework count in their course grade at some level.

In the second part of the survey, we surveyed students about eight actions a faculty or university could take to encourage homework completion. Table 3 contains full results. The scale for the responses is 1 to 4, with 1 representing the action would cause the student to complete less homework, 2 representing no effect, a 3 indicating the student felt the action would cause him or her to complete slightly more homework, and a 4 indicating that the student would complete much more homework. In the table, we rank (p-value < 0.05 on differences) the responses from what the students felt would most contribute to homework completion to least.

Table 2: Course Policies

Homework format preferred:	
Textbook	45.4%
Worksheet	32.1%
Online	7.7%
No preference	14.8%
Percentage of final grade that should be determined by homework:	
0%	9.9%
5-10%	42.4%
15-25%	35.4%
30-40%	9.0%
More than 40%	3.3%
Amount of time that should be spent on homework per class period:	
0-30 minutes	15.3%
30-60 minutes	46.5%
60-90 minutes	23.5%
90-120 minutes	11.3%
More than 120 minutes	3.5%
I prefer to have shorter homework that would leave off problems that help with exams:	
Strongly disagree	32.2%
Disagree	53.5%
Agree	10.5%
Strongly agree	2.6%

Table 3: Faculty or University Actions to Encourage Homework Completion

	Faculty Action	Mean
1	Using questions from the assignment on the exam	3.60
2	Quizzes with problems directly from the homework	3.43
3	Grading the homework for completeness	3.19
	Answers available for all problems	3.18
	Grading the homework for correctness	3.02
6	Each assignment has a 50% chance of being collected	2.85
	More tutoring and/or office hours available on campus	2.70
	Instructor facilitating the formation of study groups	2.58

The graph in Figure 1 below illustrates the breakdown of student responses for each question in the second part of the survey. For each of the two most popular responses ("Using questions from the assignment on the exam" and "Quizzes with problems directly from the homework"), almost 90 percent of E/ET students indicated that they would complete either slightly or much more homework. All but "Instructor facilitating the formation of study groups" were given a score of at least 3 by more than 50% of the students.

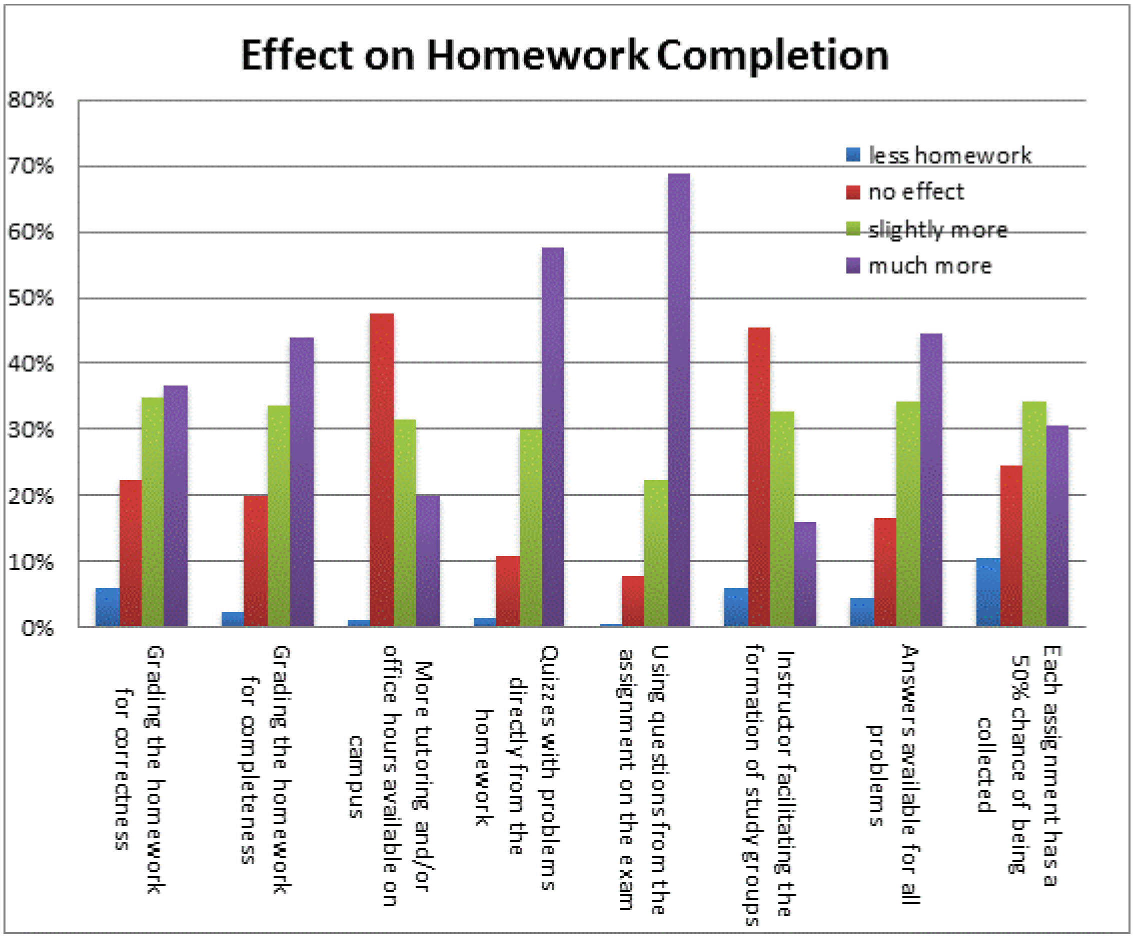

Figure 1

Table 4 contains results from the final portion of our survey, where we attempted to determine why assignments are not completed. In this section, students again used a scale of 1 to 4, where a 1 indicates the factor never contributes to an incomplete assignment, 2 indicates the factor rarely contributes to an incomplete assignment, 3 indicates sometimes, and 4 often. The responses are again ranked from what the students reported as contributing most often to contributing least often (p-value < 0.05 on differences).

Table 4: Factors Contributing to an Incomplete Assignment

	Reason for not completing homework	Mean
1	You had too much work from other courses	3.15
2	You had commitments outside school that took too much time	2.89
3	You waited until the last minute and ran out of time	2.58
	No solutions were available to assist you	2.55
	The lecture did not prepare you for the assignment	2.51
6	You knew it wouldn't be graded	2.32
	You already knew the material	2.21
	You forgot about the assignment	2.12
	You just didn't feel like it	2.00

Here there was less agreement among students. The graph in Figure 2 summarizes the student responses. The only factors selected as sometimes or often contributing to a lack of homework completion from more than two-thirds of the students were "Too much work from other courses" and "Outside commitments took too much time".

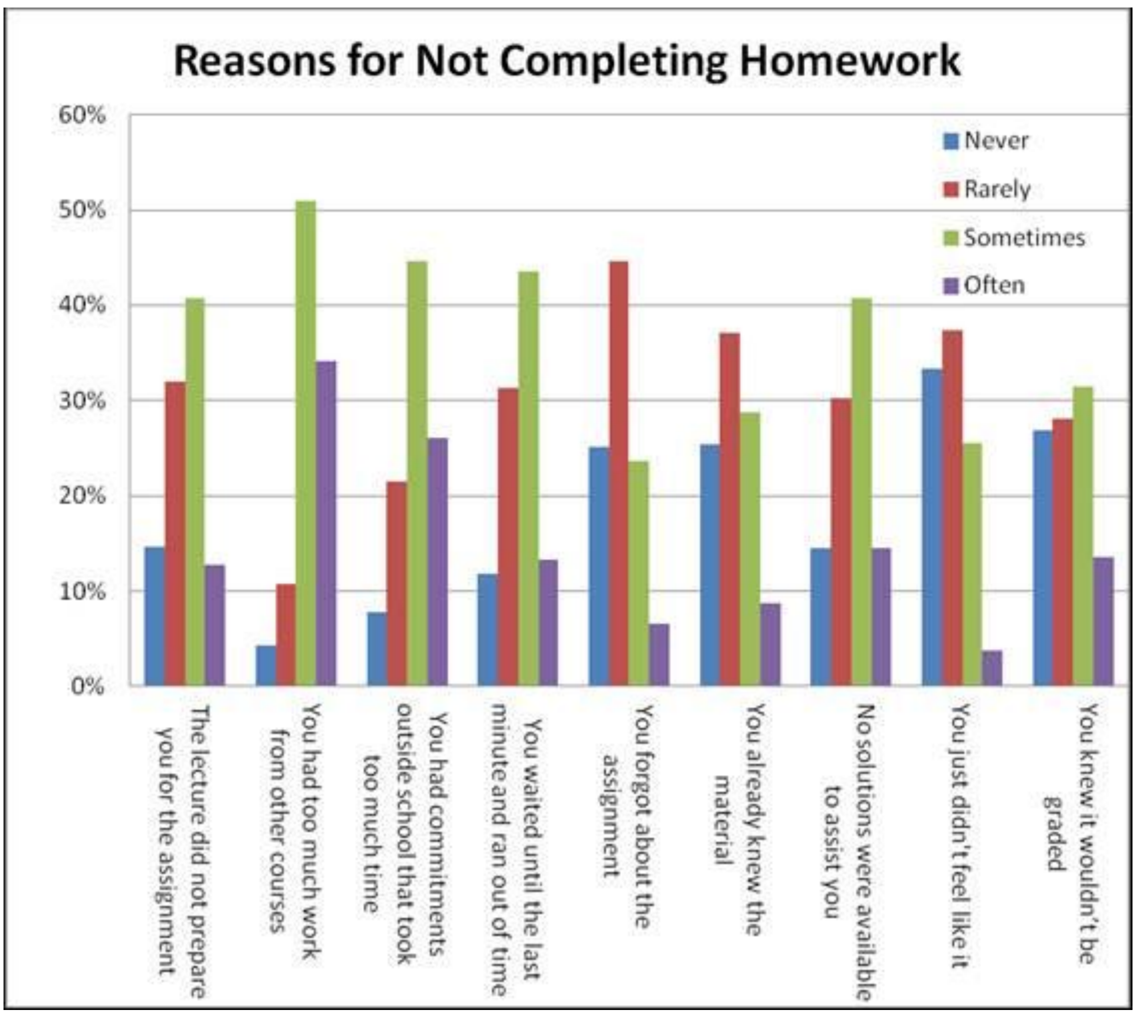

Figure 2

Conclusions and Future Work

We acknowledge that the validity of the data reported here relies on the ability of students to answer the questions honestly, and certainly students will not always have done so. For this reason, our conclusions below focus on using this data as a starting point for future research, rather than using it as justification for definitive best practices in the area of homework policies.

Approximately half of the E/ET majors felt that 30-60 minutes of homework per class period was appropriate, and another 15% felt that even less was the correct amount. This is in direct conflict with their overwhelming rejection of shorter assignments that may leave off questions that would prepare them for the exam. This is a discouraging outcome; it indicates a true disconnect between E/ET students' perceptions of the time that should be needed to master course material at the college level and the actual time needed for mastery. Investigating reasons behind students' misperception and ways in which their expectations can be brought in line with those of their instructors would be an interesting and important future direction to study.

A more encouraging outcome of the study is the indication that students believe a wide range of policies would increase their homework completion. In particular, the two that students believe would be most motivating – using homework problems on exams and on quizzes – are both very easy to implement. There may be some concern about whether instructors are truly testing mastery of the material if exams involve questions (even in part) that students have seen before. The tradeoff between increasing learning through additional homework completion versus increasing learning by challenging students to solve problems they have not seen before would be another important area of study.

We also note that there was no statistically significant preference expressed between grading homework for completion and grading for correctness. This would seem to give an instructor the freedom to choose whichever approach he or she prefers, although certainly this warrants future study. In addition, grading homework for completion is generally not very time-consuming, so this is again a policy that could be implemented with relative ease that may have a positive effect on homework completion rates.

In our opinion, the results concerning why students do not complete homework are not very reliable. For example, around 70% of students claim that they rarely or never fail to complete a homework assignment because they did not feel like it or they forgot. Based on our experience, we do not believe that this is accurate, nor do we find it surprising that students would be unwilling to cite these as reasons for not completing their homework. In order to get a more accurate result, it may help to survey students over the course of a semester each time a homework assignment is due.

Students do seem to feel that a lack of time – either due to other classes or due to outside responsibilities – contributes significantly to their ability to complete their homework. Various interventions to solve this problem are already being tested at many universities, including improved advising and mandatory orientation courses to teach better time management skills. We believe that an important component of these studies would be to investigate whether they affect students' perceptions of whether they have time to complete their homework.

Encouraging E/ET students to complete more homework in their mathematics courses seems essential to training the next generation of engineers. In addition to providing insights toward possible effective classroom policies, we hope that the results of this survey can inform future rigorous research, helping mathematics education researchers to focus on the most pertinent variables in their experiments.

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