Student Perceptions of Online Statics Homework Tools

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***Abstract*—The face of engineering education continues to change as the use of online and computer-based tools grows. To guide this growth, this study sought to identify which characteristics students prefer in their homework format. The researchers used a survey during two semesters, soliciting feedback from 60 students in undergraduate Statics courses. Responses indicated that providing worked examples greatly influenced student appeal toward an online homework system, and that the most preferred characteristics of any homework format were 1) the ability to attempt problems multiple times, 2) to stop/start at their own pace, 3) to receive immediate feedback, and 4) to receive detailed and valuable feedback. The findings of this study can guide educators, administrators, and software designers towards formats that meet the preferences of current undergraduate engineering students.**

***Index Terms*—Homework, Stated preference, Statics, Worked examples**

I. INTRODUCTION

Technology continues to advance the world of engineering, opening opportunities to advanced teaching methods for future generations. Overall, online college enrollment has grown at a rate of at least 9% for the years 2003-2013 [1]. Although a study published in 2005 noted that the engineering field had lagged in use of digital coursework [2], subsequent work noted a twelve percent increase in online enrollment between the years 2006 and 2007 alone [3]. These studies noted that laboratory and hands-on portions of engineering courses are extremely difficult to transfer to a digital or online environment. In order to help move engineering education into the future, there have been several studies that look into the advantages and disadvantages of moving either a portion or entire courses online.

The online homework system used at Southern Illinois University Edwardsville (SIUE) is based on the study of worked examples. The examples were designed according to the principles of "cognitive load" described by Sweller [4] and other researchers in educational psychology and contained detailed explanations of every step in the solution process. Students were assigned an example to study and then had to solve an online homework problem which was 1) sufficiently similar to the example problem that the student knew the general approach to take, but 2) sufficiently different from the example problem that the student could not rely on thoughtless pattern matching to obtain an answer. Fig. 1 shows a representative worked example and Fig. 2 shows the paired online homework problem.

When completing each homework problem, if students submitted an incorrect answer, they were given the correct answer and then were allowed to attempt the problem up to nine more times. Each time, however, the computer changed some of the given data (for example, a length or a force magnitude), so that the answer changed. Students' scores on the online homework problems were recorded and contributed a small amount to the overall grade for the course.

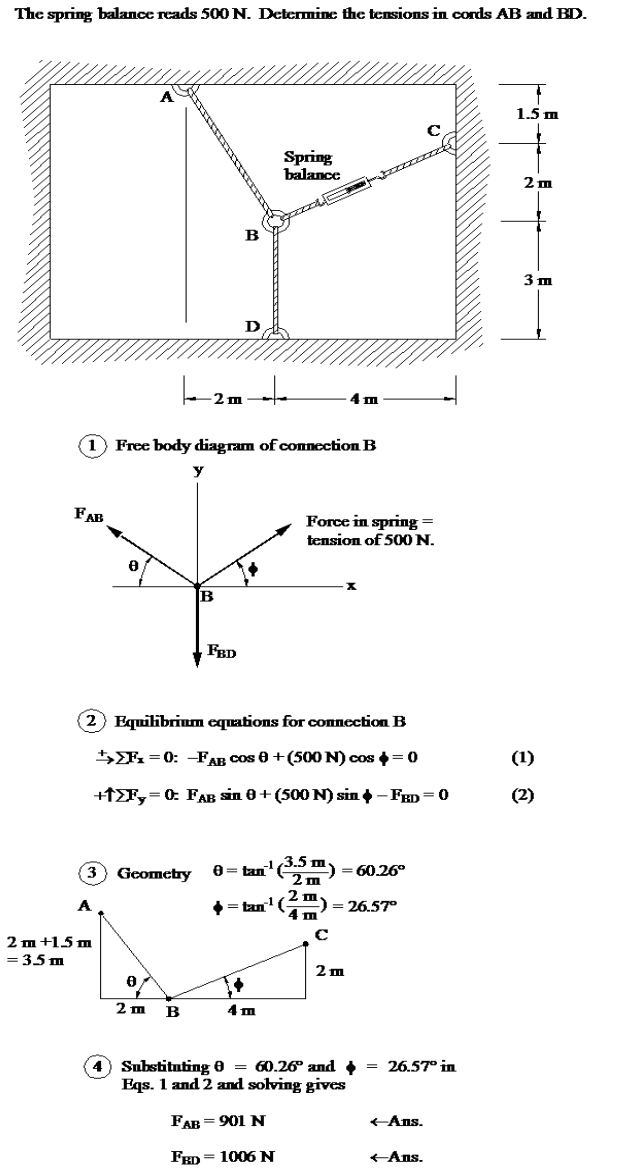


Figure 1. Sample Worked Example for Described Homework System

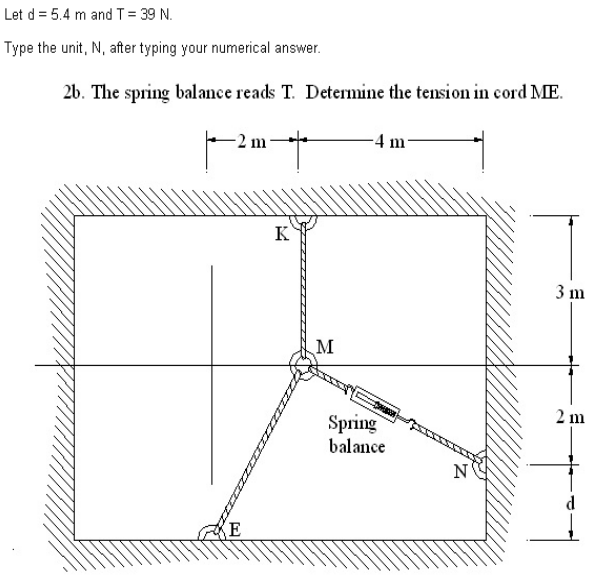


Figure 2. Homework Problem for the Worked Example from Fig. 1

Faculty implemented this online homework system because of increasing section sizes of Statics classes. The system has helped to manage faculty and teaching assistant workload while still providing problem-solving feedback to students. The online homework problems integrate with the University's learning management system, Blackboard, and has scaled to sections of approximately 100 students. There is no indication that this system could not be expanded to 1000s of students with modest increases in computer servers. Further, this homework system ensures consistency between different instructors and across semesters.

In the engineering Statics course at SIUE, this online homework has been implemented in whole or in part for the past several years. During the spring and fall semesters, online homework was the only type of homework given and an extensive library of worked examples was provided. In the summer semester, the homework was a mix between paper-based and online homework, but no worked examples were provided. The course material was nearly identical because instructors shared their notes. Additionally, the instruction method for both semesters was largely traditional blackboard/ whiteboard lectures with some Power Point. This Statics course was evaluated over two semesters, as a test base for different styles of homework and students' perceptions of them. The objective of this study was to identify the underlying factors that influence students' perceptions and preferences about homework format.

II. PREVIOUS WORK

Mathematics and science-based courses have had limitations with electronic homework in the past due to the necessity of conceptual manipulation on a significantly larger scale than other, text-based, courses. A major constraint used to include the limitations on the ability to deploy equations on a digital level that are easy to manipulate and compute [1]. Because more multi-step hands-on materials are covered in engineering than other disciplines, giving feedback on the correct or incorrect methodology could be more challenging. A study by researchers at Stanford University showed that as technology has improved, the ability to teach more complicated materials has grown equally. For example, instructors can now use online office hours to solve student problems with a digital whiteboard [3]. With the growth in technology and online teaching theory, more opportunities have arisen to digitize homework in engineering based courses. For example, see the work by Steif and Dollar [5].

A study in hybrid teaching methodology by Peercy and Cramer (2011) states: "students learn more from an online setting than from a strictly traditional setting, but students learned more than either when a hybrid approach was used."[6] Hybrid teaching methodology is a bridge between traditional and online schooling. One method of hybrid teaching that pertains to this study includes the use of traditional teaching to cover materials for the class, while requiring all example problems and homework to be covered digitally. By continuing to require student participation in a traditional classroom setting while implementing online worked examples [4], homework, and possibly quizzes, the worry of losing the hands-on, laboratory portion of an engineering education can be dismissed. Moving some of the material covered in class to an online format will allow more time in class to answer questions and cover the material effectively.

Mackey and Freyberg completed a study in 2010 about how grades are affected when teaching in online versus traditional formats. During this study, a class was taught traditionally in Nanyang Technological University (NYU) in Singapore, and taught online at Stanford University. The study showed that using online over traditional coursework had little-to-no effect on the outcome of student grades, but it did have an effect on student satisfaction. Thus, by changing the distribution of homework to a digital format, education will be catering to the growth of the technological age with little negative effects on the quality of learning [1].

Examples of online engineering systems include YourOtherTeacher.com, which is the parent company of Statics.com. Both are designed to teach, give examples, and practice problems. YourOtherTeacher.com focuses on math from algebra to finite math and Statics.com has over 300 videos to improve a student's understanding of statics in all areas [7]. Several studies suggest student learning is equal if not better with similar online homework [8,9,10,11].

Most similar to the current research, a study about online homework in economics courses at the University of Minnesota Duluth showed that overall, switching to online homework was successful and has several valuable attributes. Some of the more prevalent attributes include the time flexibility for students to complete the assignments and the immediate feedback in order to gain further understanding of the material where necessary. The use of online homework also has the added benefit of giving the instructor more time to prepare for other aspects of class work due to the fact that the online program should grade the assignment and give mild preprogrammed feedback to the students [12].

The growth and development of technology in the world of education dictates that a change towards online education is almost required to teach newer generations effectively. As the culture is moving towards social and

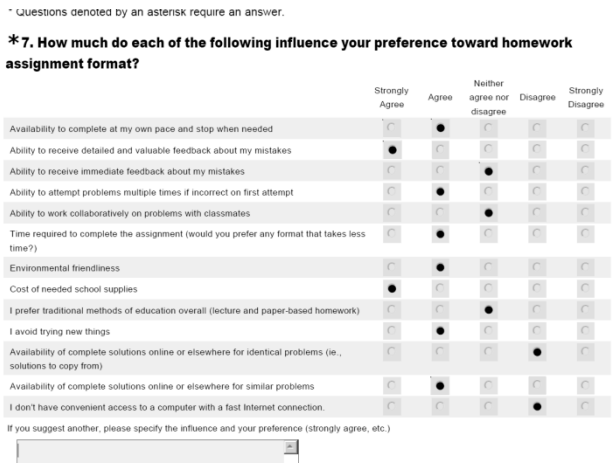
online media for more forms of interaction, it is becoming apparent that information passed along using a digital format can be better at soliciting student interest compared to traditional methods of teaching. It is suggested that "there are physiological changes in the brain of digital natives that could be the result of changed brain development or at least a strongly developed different way of thinking and processing information" [6]. These changes that have occurred in response to digital advancements require that teaching methods evolve to fit the needs of current and prospective students better.

Several studies have examined the timing and content of feedback. Balzer et al. (1989) identified that task information was the most effective type of cognitive feedback to improve student performance [13]. McKendree (1990) found that students completing online homework provided with more-specific feedback improved their problem solving skills more than those that were solely informed correct or incorrect [14]. More recently, Mathan and Koedinger (2005) identified that delayed feedback on student errors promotes deeper learning than immediate feedback. Providing students with opportunities to identify and correct their own mistakes was an important step in the learning process that can be stifled if feedback is provided immediately after each error [15]. Thus, students learn better when feedback is targeted towards correcting the problem-solving process and is only given at set intervals.

Overall, these past studies conclude that online homework requires less time for instructors to grade and administer and has little impact on grades. If faculty use online homework in conjunction with traditional classroom time, it has the potential to increase student learning compared to traditional homework assignments. To retain these potential gains in learning however, online homework guidance should be timed and focused to encourage critical thinking for problem solving and concept application rather than providing merely an opportunity for concept repetition. Furthermore, studies have demonstrated that students are likely more satisfied with online homework because of the convenience. Although these studies show strong support for using online homework systems, little is known about what other factors influence students' preference for online homework, particularly in engineering courses.

III. METHODOLOGY

Researchers at SIUE created, refined, and launched a web-based survey in the summer and the fall of 2012. The survey contained 24 questions broken into three primary sections. The first section included five questions about students' overall preferences on homework format. The next section included a series of 14 Likert-scale questions about how much different factors influence their homework preferences, as displayed in Fig. 3. The last section included five questions about the student's demographics.


* Questions denoted by an asterisk require an answer.

***7. How much do each of the following influence your preference toward homework assignment format?**

	Strongly Agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Availability to complete at my own pace and stop when needed	○	●	○	○	○
Ability to receive detailed and valuable feedback about my mistakes	●	○	○	○	○
Ability to receive immediate feedback about my mistakes	○	○	●	○	○
Ability to attempt problems multiple times if incorrect on first attempt	○	●	○	○	○
Ability to work collaboratively on problems with classmates	○	○	●	○	○
Time required to complete the assignment (would you prefer any format that takes less time?)	○	●	○	○	○
Environmental friendliness	○	●	○	○	○
Cost of needed school supplies	●	○	○	○	○
I prefer traditional methods of education overall (lecture and paper-based homework)	○	○	●	○	○
I avoid trying new things	○	●	○	○	○
Availability of complete solutions online or elsewhere for identical problems (ie., solutions to copy from)	○	○	○	●	○
Availability of complete solutions online or elsewhere for similar problems	○	●	○	○	○
I don't have convenient access to a computer with a fast Internet connection.	○	○	○	●	○

If you suggest another, please specify the influence and your preference (strongly agree, etc.)

Figure 3. Likert-Scale Question Grid used to Collect Preferences

To ensure the validity of the findings, the researchers addressed mutual exclusiveness through the number of allowable answers to each question. For example, when the possible choices were not mutually exclusive, the survey form allowed respondents to select all that apply. When the choices were mutually exclusive, the respondents could only select one. Additionally, the researchers included places for respondents to add their own answers, titled "other" on almost all questions. After this survey was designed and refined, the researchers piloted the survey using a small expert panel that included three faculty members and a student, as guided by Czaja & Blair [16].

Participants were solicited from students enrolled in undergraduate Statics courses at SIUE during the summer and fall semesters of 2012. Note that the summer semester class met during the evening twice a week, two hours and forty minutes each, for eight weeks; and the fall semester course met twice a week during the day, for one and a quarter hours each, for fifteen weeks. Because student responses in the survey were anonymous, the researchers created a unique code at the end of each completed survey that could be validated, but not linked to a particular respondent. The students were encouraged to send the code to their statics instructor to earn a small amount of extra credit in the course.

After participants completed the survey, the researchers applied established statistical techniques to draw conclusions both between and across semesters. The following two sections describe these findings and how they support the conclusions.

IV. FINDINGS

The findings of the survey are presented in the following order: demographics of respondents, factors influencing student preferences on homework format, and relation between homework location and level of collaboration.

Demographics

The average age of the 60 survey respondents was 20.6 years old and there was approximately an 80/20 (percent) split between male and female participants, respectively. As expected, the majority of students (61%) were sophomores, some (37%) were juniors, and a few (2%) were seniors. Nearly three quarters of the students were

either Civil or Mechanical Engineering majors as shown in Fig. 4. These demographics were consistent between the two semesters of the study. Because these demographic characteristics are likely representative of Statics courses at other Universities, the findings could be transferable to many other institutions.

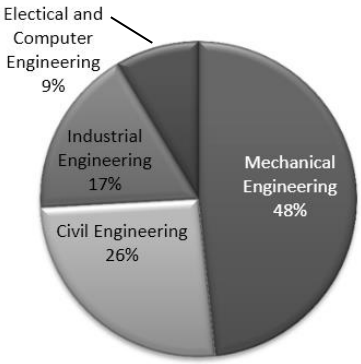


Figure 4. Survey Participant Reported Majors

Student Performance

To evaluate the similarities in student performance between the study semesters, the researchers compared the distribution of final course grades for the 2012 summer and fall semesters. SIUE transcripts denote final grades as whole letters, not including any pluses or minuses. Review of these grades showed that students performed better during the fall semester than during the summer. As Fig. 5 illustrates, students earned seven percent less Ds and 13% less Cs during the fall semester, compared to the summer. Note that the percentage of Fs and withdraws (W) were identical between these semesters. Although these specific grades suggest that students performed better with the online homework system, our faculty have not noticed any major differences since the implementation of the online homework system.

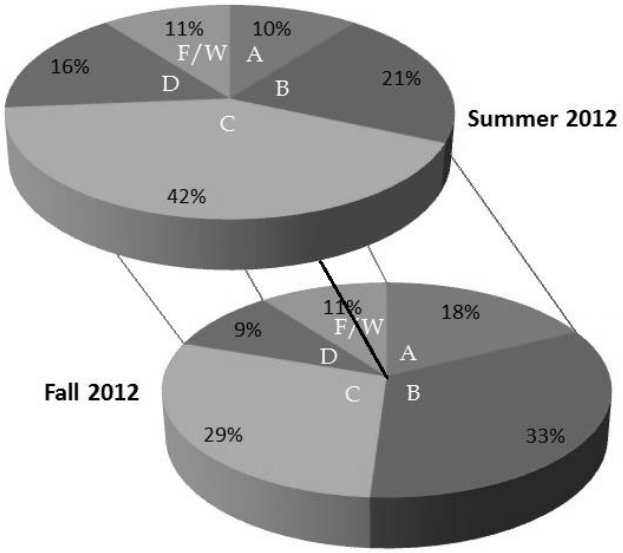


Figure 5. Student Final Grade Distributions During Study

Factors Influencing Student Homework Preferences

The first key finding of this study was that providing worked examples significantly influenced student's preference for online homework. As previously mentioned, the fall course provided students with an extensive library of fully-worked example problems, but the summer course did not guide students to these resources. Although this lack of guidance was unintentional, the study revealed some interesting findings. As displayed in Fig. 6, the homework format preference between these two semesters was notably different. Because the demographics and detailed preferences were similar between semesters, there is no indication that the student population was different between these semesters.

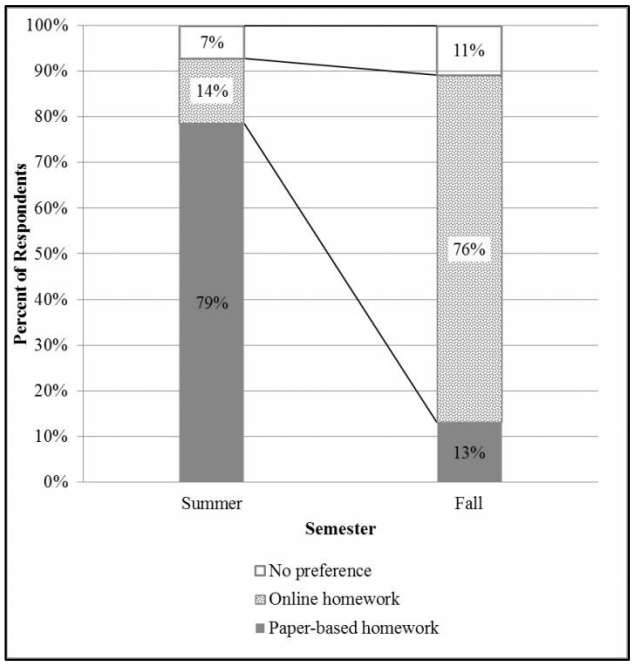


Figure 6. Student Homework Format Preferences between Semesters

Researchers expected that students would strongly favor the online homework based findings of previous studies [12]. Because only students from the fall semester preferred online homework, the findings suggested that worked-examples are important from the student perspective, supporting their use [17]. The worked example approach could be appealing to students because it reduces the need for detailed feedback on their work. Although the actual online homework implemented is just a fill-in-a-number approach without detailed feedback, the student's frustration is quite a bit lower with the worked examples than it would be without (hence the higher satisfaction seen in the group that had the worked examples to study during homework). This result is promising for instructors because the worked example approach is much easier to implement than detailed feedback on each item of student work.

The researchers also compiled the detailed student ratings of specific homework format characteristics. Because the survey collected student preferences using a Likert-type ranking [18] and because this portion of the survey was designed as a series of questions, a Likert-scale analysis was most appropriate [19]. During this analysis, the following scale was applied: Strongly Agree=5, Agree=4, Neither agree nor disagree=3, Disagree=2, Strongly disagree=1. Based on the findings from the survey, the most important factors that influenced student homework format preferences were:

1. Ability to attempt problems multiple times if incorrect at first (rated 4.63)
2. Availability to complete at my own pace and stop when needed (rated 4.46)
3. Ability to receive immediate feedback about my mistakes (rated 4.38)
4. Ability to receive detailed and valuable feedback about my mistakes (rated 4.29)
5. Ability to work with classmates (collaboratively) on assignments (rated 3.90)
6. Availability of complete solutions for similar problems (3.93)

To determine if there were significant differences between these student preferences, researchers calculated 95-percent confidence intervals and examined the overlap for the responses. These findings are shown in Fig. 7, where the squares represent the average student rating and the dark vertical bars represent the confidence intervals. Note that preferences with confidence interval overlaps were not statistically different at the 95-percent level.

The researchers have grouped these student preferences into four groups as shown in Fig. 7. Most importantly, the four characteristics in group one were rated significantly higher than almost every other. Note that the overlap between groups one and two indicate that the "ability to receive immediate/detailed… feedback" is in both groups one and two.

Comparing these findings to those from Doorn et al. [12], we note that similar trends between engineering and economics students. Additionally, the confidence interval analysis conducted herein enabled deeper comparison of the different factors that influence students' online homework preferences.

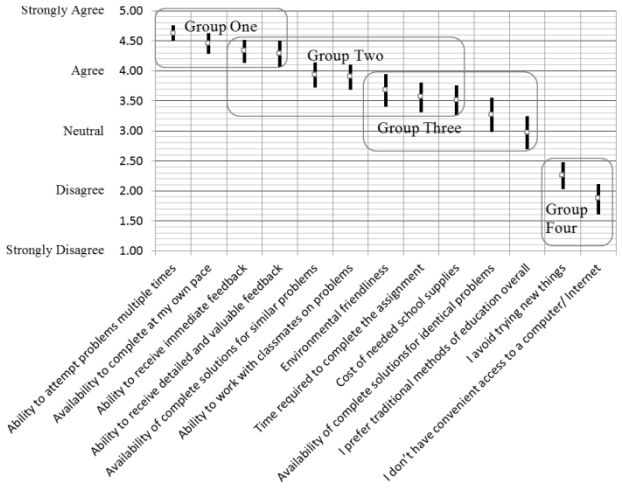


Figure 7. 95-Percent Confidence Intervals of Homework Format Preferences

The next most important finding is shown as group four in Fig. 7. Students strongly disagreed with the idea of avoiding new things or lacking computer access. This opposition was so strong that these two characteristics were significantly lower than any other; therefore, students' opinions on homework format are not likely affected by new or online formats.

To provide further clarification between the top homework characteristics, the authors reviewed the 90-percent confidence intervals. As Fig. 8 demonstrates, there is weak evidence that the first four homework characteristics are preferred significantly more than the others. Again, groups have been identified by boxes.

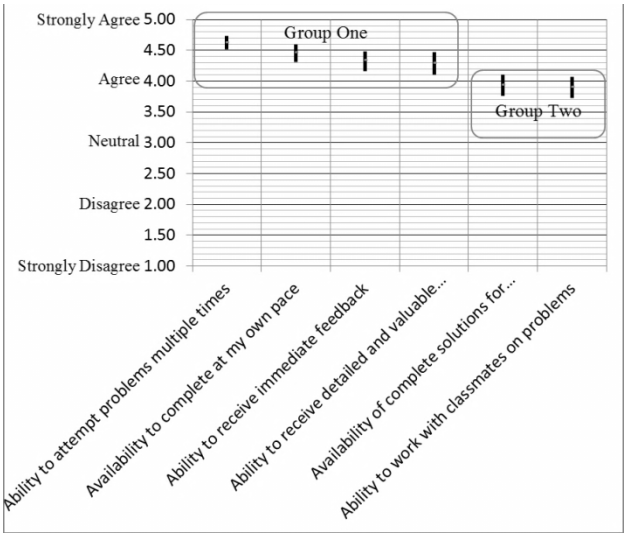


Figure 8. 90-Percent Confidence Intervals of Homework Format Preferences

The remaining findings from this statistical analysis propose a rank of these homework preferences. Although not all of the preferences in groups two and three can be statistically differentiated, the results can provide valuable guidance to those working to develop or improve homework assignments for Statics and other courses with similar student demographics.

Location and Collaboration

During analysis, researchers suspected a correlation between the location where students completed their homework and how they completed their homework. Although 77 percent of students reported completing their homework alone, the researchers tested the hypothesis that those students completing homework on campus were more likely to collaborate with other students than those completing their homework at home. Table 1 shows the results from a correlation analysis. The findings suggested that students completing their homework at home (67% of respondents) were unlikely to collaborate with others. This conclusion is supported by the correlation of 0.39 for those completing their homework alone, and -0.38 for those completing their homework collaboratively. Additionally, responses from students completing their homework on campus had a correlation of -0.25 with those completing their homework alone and a correlation of 0.22 with those completing their homework collaboratively. Overall, this data suggests that students are more likely to collaborate with each other when they commonly complete their homework on campus.

TABLE I.
CORRELATION (R) BETWEEN HOMEWORK COMPLETION LOCATION AND STUDENT COLLABORATION

	Alone, checking my solutions online after each problem	Alone, checking my solutions with a book & asking classmates when stuck	Complete Homework Alone	Collaboratively with a classmate throughout a problem set
Complete Homework on Campus	-0.18	-0.04	-0.25	0.22
Complete Homework at Home	0.26	0.08	0.39	-0.38

There is evidence of a relation between the location where students complete their homework and if they collaborate with other students or not. Because the student ratings of, "Ability to work collaboratively on problems with classmates" in Fig. 7 was not notably high, it was not likely a key factor in choosing the location to complete their homework. These finding suggest that many students chose their homework environment first (home or campus) and then decided on collaboration activities, not the other way around. Because previous research has found that students learn more efficiently from a collaborative setting [20], perhaps instructors should encourage students to complete their assignments on campus collaboratively.

V. CONCLUSIONS

Students in undergraduate Statics courses at Southern Illinois University Edwardsville were surveyed about their preference of homework format during two different semesters. The study revealed that worked examples are an essential part of any online homework system. Without such guidance, students strongly preferred traditional paper-based homework assignments where they had similar example problems from a textbook.

The top four characteristics that students preferred in their homework assignments were: the ability to 1) attempt problems multiple times if they are incorrect at first, 2) complete at their own pace and stop when needed, 3) receive immediate feedback about their mistakes, and 4) receive detailed and valuable feedback about their mistakes. Previous studies have suggested that the ability to provide detailed feedback about methodological mistakes has been a challenge constraining engineering educators; therefore, there is a demand for homework systems that are able to provide detailed feedback about student errors.

When students had worked examples to study while completing online assignments, their satisfaction with the online assignment was greatly enhanced. Because the worked example approach is generally easier to implement than detailed feedback on online homework, its development should be more fully examined as a surrogate for detailed feedback.

This study also found that students completing homework on campus were much more likely to work collaboratively with other students compared to those working on their homework at home, regardless of homework format. Because of the benefits of collaborative homework, perhaps instructors should encourage students to complete these assignments on campus.

Because the student demographics from this study are likely similar to Statics courses taught at other engineering schools, these findings could be transferrable. In particular, those considering, currently using, or developing online homework systems might find this information valuable. Future research could identify the characteristics of worked examples that make them valuable to online homework preferences.

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