Student Perceptions of Online Homework Tools in Undergraduate Statics Course

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1. Abstract

The use of electronic tools is growing in engineering education. To improve the use of online homework tools, this study sought to identify which characteristics student prefer in their homework format. The researchers used a survey during two semesters, soliciting feedback from 60 students in undergraduate Statics courses. This study found that providing worked examples greatly influenced student preferences of an online homework system, and that the most preferred characteristics of any homework format were the ability to attempt problems multiple times and to stop/start at their own pace. The findings of this study can guide educators, administrators, and software designers towards formats that meet the preferences of current undergraduate engineering students.

2. Introduction and Background

As technology continues to advance the world of engineering, it also opens opportunities to advanced methods of teaching the future generations. Although a study published in 2005 noted that the engineering field had lagged in use of digital coursework\(^1\), subsequent work noted a twelve percent increase in online enrollment between the years 2006 and 2007 alone\(^2\). 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 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\(^3\) 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. Figure 1 shows a representative worked example and Figure 2 shows the paired online homework problem.
2. The spring balance reads 500 N. Determine the tensions in cords AB and BD.

\[ \text{Force in spring = tension of 500 N.} \]

Equilibrium equations for connection B

\[ \sum F_x = 0: -F_{AB} \cos \theta + (500 \text{ N}) \cos \phi = 0 \]  \hfill (1)

\[ \sum F_y = 0: F_{AB} \sin \theta + (500 \text{ N}) \sin \phi - F_{BD} = 0 \]  \hfill (2)

Substituting \( \theta \) = 60.26° and \( \phi \) = 26.57° in Eqs. 1 and 2 and solving gives

\[ F_{AB} = 901 \text{ N} \quad \text{Ans.} \]

\[ F_{BD} = 1006 \text{ N} \quad \text{Ans.} \]

\textbf{Figure 1: A Representative Worked Example for the Homework}
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.

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 systems, 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 share their notes. Additionally, the instruction method for both semesters was largely Blackboard 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

**Figure 2: The Online Homework Problem for the Worked Example from Figure 1.**

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this study was to identify the underlying factors that influence students’ perceptions and preferences about homework format.

3. 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. Because more multiple step hands-on materials are covered in engineering, 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. With the growth in technology and online teaching theory, more opportunities have arisen to digitize homework in engineering based courses. See the work by Steif and Dollar.

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.” 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, 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.

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. Several studies suggest student learning is equal if not better with similar online homework.

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\textsuperscript{10}.

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 all 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”\textsuperscript{15}. 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\textsuperscript{11}. 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\textsuperscript{12}. 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\textsuperscript{13}. 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.

4. 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 Figure 3. The last section included five questions about the student’s demographics.
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. Participants were solicited from students enrolled in undergraduate Statics courses 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 instructor the code 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.
5. 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 amount of collaboration.

5.1 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 Figure 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: Reported Major of Survey Participants]

5.2 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 Figure 5 displays, the homework format preference between these two semesters was vastly different. Because the demographics and detailed preferences were similar between semesters, there is no indication that the student population was different between these semesters.

Researchers expected that students would strongly favor the online homework based findings of previous studies\textsuperscript{10}. 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\textsuperscript{15}. 

<table>
<thead>
<tr>
<th>Major</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical Engineering</td>
<td>48%</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>26%</td>
</tr>
<tr>
<td>Industrial Engineering</td>
<td>17%</td>
</tr>
<tr>
<td>Electrical and Computer</td>
<td>9%</td>
</tr>
</tbody>
</table>
The researchers also compiled the detailed student ratings of homework characteristics. Because the survey collected student preferences using a Likert-type ranking and because this portion of the survey was designed as a series of questions, a Likert-scale analysis was most appropriate. 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 Figure 6, where the squares represent the average student rating and the dark bars represent the confidence intervals. Note that preferences whose confidence intervals overlap were not statistically different at the 95-percent level.

The researchers have grouped these student preferences into four groups as shown in Figure 6. 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., we note that similar trends between engineering and economics students. Additionally, the confidence interval analysis conducted herein enables deeper comparison of the different factors that influence students’ online homework preferences.
The next most important finding is shown as group four in Figure 6. Students strongly opposed 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 affected by new or online formats.

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.

Within group three is the scale for the preference that students express regarding copying assignments (i.e., cheating): “Availability of complete solutions for identical problems”. There is not a strong statistical indication that students prefer this option but it is impossible to determine if students are being honest regarding this ethical issue.
5.3 Location and Collaboration

During analysis, researchers suspected a correlation between the location where students completed their homework and how they completed their homework. Specifically, the researchers tested the hypothesis that 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 highest values were found from students completing their homework at home (67% of respondents), where a correlation of 0.39 was found with those completing their homework alone, and a -0.38 correlation was found with 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.

<table>
<thead>
<tr>
<th>Location of Homework</th>
<th>Alone, checking my solutions online after each problem is complete</th>
<th>Alone, checking my solutions with a book and asking classmates only when stuck</th>
<th>Complete Homework Alone</th>
<th>Collaboratively, with a classmate throughout a problem set</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complete Homework at Home</td>
<td>0.26</td>
<td>0.08</td>
<td>0.39</td>
<td>-0.38</td>
</tr>
<tr>
<td>Complete Homework on Campus</td>
<td>-0.18</td>
<td>-0.04</td>
<td>-0.25</td>
<td>0.22</td>
</tr>
</tbody>
</table>

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 Figure 6 was not notably high, it was not likely a key factor in choosing the location to complete their homework. These findings 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\(^{18}\), perhaps instructors should encourage students to complete their assignments on campus collaboratively.

6. 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, homework systems that can provide detailed feedback about student errors have the ability to speed up implementation.

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, 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.

7. References


