# WIP: An On-going Analysis of the Impact of Assigning Online Thermodynamic Homework in place of Traditional Homework

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## Introduction

With increasing enrollment, there exists a lack of resources for implementing instructional aides without taxing instructors. To relieve the burden on instructors the use of online tools has become a popular option in higher education. Online homework has been a readily used resource in many institutions for various subjects including mathematics, physics, chemistry, and engineering. The authors' institution, Louisiana Tech University, has had plenty of experience with the open-source, freely available homework delivery tool WeBWorK. Currently, WeBWorK has been used as a homework tool in mathematics and engineering courses, including statics and mechanics of materials and circuits.

This work is part of a funded National Science Foundation (NSF DUE #1244833) project with the aim of expanding the use of WeBWorK into the engineering fields. Specifically, the project looked into the implementation of WeBWorK into three semester-long, sophomore-level, core courses: Statics and Mechanics of Materials, Electrical Engineering and Circuits I, and Thermodynamics. Prior work has been done examining the use of the online system in the courses on circuits [1] [2] and statics and mechanics of materials [3]. The problems created for these courses can found on the WeBWorK Open Problem Library (OPL) and are maintained by the developers of WeBWorK and the Mathematical Association of America (MAA).

Assignments delivered through WeBWorK offer students unique problem sets by giving them parameters that define the specific properties of a given problem. Variable parameters can be randomized to create unique problems for each student to minimize cheating. However, WeBWorK does offer a helpful feature that allows instructors to view a student's specific parameter set for any given problem, thus allowing for more specific assistance if a student requests help. For most problems, students are given blanks to submit answers. When submitted, students receive instant feedback about the correctness of their submission. Submission limits can be placed on specific problems to deter students from guessing. Intermediate results or "checkpoints" can be implemented into problems to allow students to use the instant feedback feature to check their solution as they work toward a final answer. The use of "checkpoints" also allows for the awarding of "partial credit", something that many students rely on for a source of points or credit toward a grade.

The use of WeBWorK as a homework delivery and grading system has many potential benefits over traditional paper homework. WeBWorK offers more rapid feedback and allows instructors to customize due dates and times. Answers can be uploaded after an assignments is due and still allow students to attempt the homework (usually for no credit) and check their solutions as a useful tool for studying for upcoming exams. The ability to randomize variables to make unique problem sets for each student minimizes cheating and encourages students to submit individual work. Unlike "for-profit" homework systems that may accompany a textbook or be purchased separately, WeBWorK is a free, open-source tool so neither students nor instructors have to handle additional expenses. In addition, problems can be customized or updated by the instructor to fit the needs of the class. The popularity of smart phones, tablets, and PCs make the systems

easily accessible for students (and instructors) to complete their assignments as long as they have internet access.

In this study, we compare student comprehension on specific thermodynamic topics after completion of WeBWorK assignments or traditional paper-only assignments. Student comprehension of select "isolated" topics was measured through the administration of quizzes immediately after homework was collected with no instructor assistance prior to or during the quiz. The authors believe that WeBWorK offers a unique and effective means of delivering and grading homework that can be beneficial to both students and instructors. If this study shows that WeBWorK does not impose a negative effect on student understanding of thermodynamic topics, then it should be considered as an alternative to traditional homework at the instructor's discretion.

**Previous Studies**

Previous studies have shown that web-based homework delivery systems have many benefits for both students and instructors over traditional homework. Studies have concluded that students found that online homework helped with understanding course material and preparing for exams through its flexibility and instant feedback [4]. Feedback has been shown to improve student learning [5], and online systems such as WeBWorK offer immediate feedback which can work effectively with course schedules. The flexibility of the system allows for the customizing of homework parameters such as assignment and due dates and times, assigning of partial credit, and limiting of attempts. These features help instructors create a constructive environment that encourages student participation and meets their learning needs. The use of online homework is extremely useful in environments where traditional paper homework would be impossible or unreasonable such as in large classes [4]. Web-based practice and assessment has been shown to build motivation in students in middle-school math classes [6]. The preference of online homework over traditional homework suggests that a diverse student population may react positively and benefit from online homework regardless of gender, academic rank, and learning style [4].

The preference of online technology as a learning tool over traditional tools has been documented at the authors' institution. A 2008 study conducted at Louisiana Tech University showed that students favored online homework over traditional homework [7]. Another study showed that the use of online homework showed significantly higher mathematical achievement in low math-skilled students compared to the same low-skilled students using traditional textbook homework [8]. Universities and colleges have reported that WeBWorK used in mathematics courses demonstrated improvement in exam scores and student performance [9]. A study conducted at Rutgers University showed that students in first-time calculus classes received higher exam grades when completing most of the WeBWorK assignments compared to students who did not complete the assignments. The study also showed that once students attempted a problem they were 94.4% likely to complete it indicating that student effort is a driving force [10]. The combination of instant feedback and multiple attempts (if allowed by the instructor) allows students to work on a problem until completion which enhances student learning and achievement [11].

Previous studies have been conducted at Louisiana Tech University in the other sophomore engineering courses. Studies conducted for Circuits and Statics and Mechanics of Materials courses showed no statistically significant difference in student performance between students assigned WeBWorK and those students assigned traditional paper homework, as measured by common quizzes given to both student groups. Student feedback showed that students felt more positive about using WeBWorK than traditional homework; many students specifically cite the instant feedback feature as extremely beneficial. Instructors for both courses also shared similar positive views because of the instant feedback and the streamline management of the homework [2] [3].

**Development of WeBWorK Problems for Thermodynamics**

The Thermodynamics course (listed as ENGR 222) at Louisiana Tech University is part of a three-course sophomore series that also includes Statics and Mechanics of Materials (ENGR 220) and Circuits (ENGR 221). Though the class is listed as a 200-level class or sophomore class, it is open to all students who have completed the freshmen engineering sequence. Topics such as energy and mass balances are covered in the freshman engineering sequence and are expanded upon in the thermodynamics course. More advance topics are covered in the course such as the analyses of cycles (e.g. refrigeration cycle) and the analyses of both closed and open systems. Regardless of engineering discipline, students should develop the knowledge to answer fundamental thermodynamic concepts such as identifying the amount energy needed for a system to undergo a state-changing process or the efficiency of a heat engine operating under specific conditions. The WeBWorK created for the course gives students the opportunity to practice and analyze problem sets over various topics, as shown in **Table 1**.

**Table 1. Thermodynamics WeBWorK Library Topics**

| **Thermodynamics Topic** [a] | **Number of Independent Problems** [b] |
|---|---|
| Unit Conversions | 3 [9] |
| Pressure | 4 [5] |
| Mechanical Energy | 7 [7] |
| **Real Properties (from property tables in textbook)** | 3 [20] |
| Ideal Gas Properties | 4 [4] |
| Closed Systems Energy Balances | 6 [16] |
| Specific Heats | 5 [9] |
| **Open Systems Energy Balances** | 9 [14] |
| Unsteady Flow Energy Balances | 2 [5] |
| Heat Engines, Heat Pumps, and Refrigerators | 5 [10] |
| **Carnot Cycles** | 6 [10] |
| Entropy | 3 [10] |
| **Entropy Changes in Solids, Liquids, and Gasses** | 9 [12] |
| Reversible Work | 2 [6] |
| Isentropic Efficiencies | 4 [7] |
| Brayton Air Cycle | 2 [9] |
| Rankine Steam Cycle | 2 [7] |
| Vapor Compression (Refrigeration) Cycle | 1 [4] |

[a] Topics in bold font were selected for quizzes.
[b] Total number of answer blanks are provided in brackets.

Many of the problems designed for the course involved multiple answer inputs. Some problems were designed to accept values from intermediate steps of a solution needed to find a final answer as shown in **Figure 1**. This particular setup is great for assigning partial credit (a feature that many students usually liked about traditional homework and grading) and serves as a guide for students while trying to identify an appropriate solution path. Students can submit their intermediate answers and receive instant feedback thus reassuring correct students and quickly correcting or warning lost students without further wasting time.

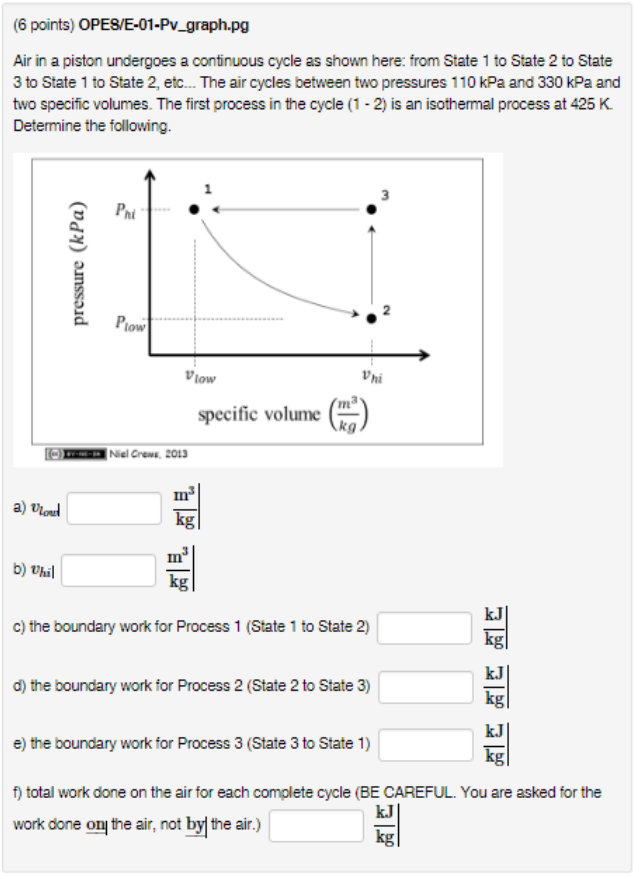


**Figure 1. Sample WeBWorK problem with multiple answer blanks.**

Many problems may require students to recall previous topics covered in the course demonstrating a more realistic integration of topics. Previous topics can be accessed and at the discretion of the instructor correct answers can be viewed for previously assigned problems. Hints can be enabled by instructors to help struggling students who repeatedly submit incorrect answers. Another useful feature is a convenient option for students to email an instructor regarding a specific problem. Students may add additional comments to the email to explain their methods and theories, while instructors are granted the opportunity to see the specific parameters assigned to the individual student. Instructors can also see previous answers submitted by the students and under most circumstances can identify gaps in the student's understanding of the problem. An example of a problem from the Thermodynamics library with many of the available features is shown in **Figure 2**.

The problem solution and the appearance of the problem are coded using Perl. Images and figures can be added as .png image files. Making edits to the code is fairly simple and instructors unfamiliar with Perl programming language should be able to make edits or corrections without much additional effort. Instructors or problem developers can easily make modifications to include more answers blanks (an efficient way of awarding "partial credit" that students like about traditional homework and grading) or to alter how answers are submitted (e.g. answers can be displayed in a multiple choice format using a "PopUp" function). WeBWorK also allows instructors to set limits on problem attempts and the tolerance for submitted answers (both methods can help reduce the tendency of students to guess on problems).

Figures and files used for the course can be found on GitHub (github.com) where numerous other WeBWorK files from other institutions can be found. (A search for "open problem library" on GitHub will lead interested users to WeBWorK files; interested parties can search for files used in this study under file names with "LaTech/opes".) The problem files, figure files, and interpolation function files can be found in the same repository.

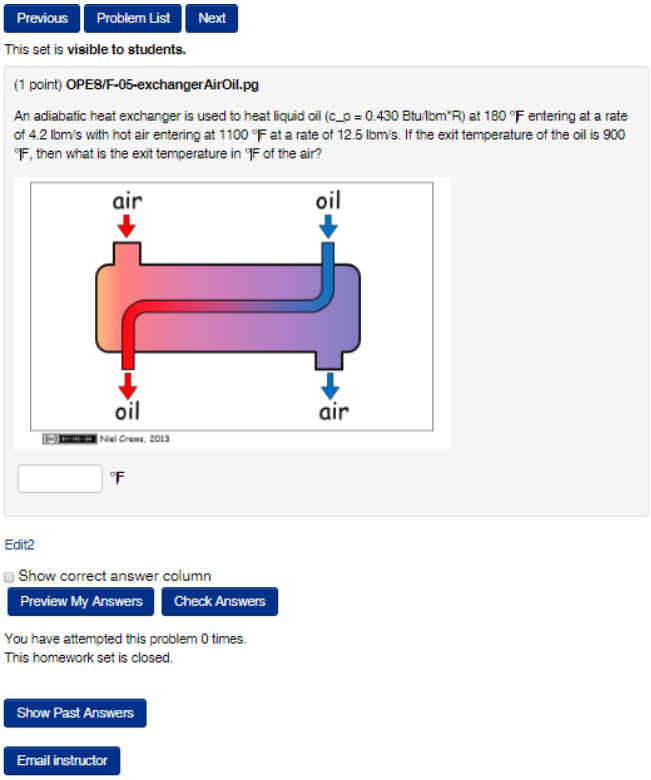


**Figure 2. WeBWorK problem display (instructor's viewpoint).**

Interested institutions can locally host the WeBWorK system free of charge if the institution has the required servers and technical support. Off-site hosting provided by the MAA for a fee is available to institutions lacking the appropriate resources or who wish to use WeBWorK on a trial basis. Additional information about applying and using WeBWorK can be found at http://webwork.maa.org/. Problem libraries created as part of this NSF-funded project can be used freely regardless of hosting site.

**Current Study of Using WeBWorK in a Thermodynamics Course**

The objective of this study is to evaluate the effectiveness of using WeBWorK as a homework delivery system for an introductory thermodynamics course. The study was conducted in the spring quarter of 2016 using three course sections. The three course sections were all taught at different times (001: 8:00 – 9:50 AM; 002: 10:00 – 11:50 AM; 003: 2:30 – 4:20 PM) under two different instructors (001 & 003: IA; 002: IB). Four homework topics were chosen to serve as the subject for quizzes and to be used in both WeBWorK and traditional homework formats. The four subjects chosen (shown in bold print in **Table 1**) were identified as "isolated" topics; in other words, these topics required little to no knowledge or mastery of previously covered topics or were considered to be independent of other topics discussed in the course.

For each of the four homework topics, each course section was divided into test groups. One group was assigned the homework in the online WeBWorK format while the second group received a printed paper-only form of the same questions. After the quiz, students who initially were given the traditional paper assignment were later "assigned" the WeBWorK assignment for no additional credit, but to provide equal exam-preparation materials to all students regardless of group assignment. For the next sequential quiz, the groups were flipped. To reduce variability, student groups were formed by splitting the alphabetical rosters into two equal groups. So for the first quiz, group A (first 50% of roster) was assigned WeBWorK and group B (last 50% of

roster) was assigned traditional paper homework. For the second quiz, group A was assigned paper homework and group B was assigned WeBWorK. For the third quiz, group C (middle 50% of roster) was assigned WeBWorK and group D (first 25% and last 25% of roster) was assigned paper homework. For the fourth quiz, group C was assigned paper homework and group D was assigned WeBWorK.

On the day of the quiz, homework was collected at the start of the class period. To ensure that quiz score would reflect the student's understanding gained from the homework, both instructors refrained from answering any questions prior to and during the short 10-20 minute quiz (instructors could clarify problem statements but refrained from giving hints during the quiz). The quizzes were graded by a common third-party (neither instructor) grader under a specific common rubric. The grader had no previous knowledge of which test groups students belonged to during the grading of the quizzes. To verify the effects of either homework format on quiz grades, any quiz grades belonging to students who did not submit homework (in either format) for that specific quiz topic were removed for the statistical analysis.

To assess student perceptions regarding the use of WeBWorK in the course, online pre- and post-course surveys were sent to the students. Both pre- and post-course surveys asked for student opinions regarding their identity and self-efficacy as engineering students. The post-course survey also had questions measuring the level of agreement to various statements regarding the use of WeBWorK as a homework delivery system and their experiences with it.

**Statistical Analysis of Quiz Scores**

A binomial generalized linear mixed effect model was used to analyze the data mainly because of the variability between baseline student performances, the missing values (from students who were absent on scheduled quiz dates or who withdrew from the course), high skewness, non-normal and the percentage form of the outcome variable of interest (quiz score), which is bounded by 0 below and 1 or 100% above. More importantly, the data gathered also included other factors like "sections", which corresponds to the different instructors and schedules, and the interaction between "sections" and "homework type". We need to control the effects of these factors to filter out or isolate the effects of the "homework types" to quiz scores. A way to do this is to use the binomial generalized linear mixed effect model which is also flexible enough to handle missing values in the data. The results of the fit tests favored the proposed model also. In our analysis, every effect testing is performed at 5% level of significance.

The model fitting above displayed a Type II Wald chi-square test, which indicated that only the homework type, class section, and interactions between homework type and class section had a significant effect on quiz scores. The chi-square test showed that of the three factors the interaction between homework type and course section has significant effect on quiz scores. This indicates that the use of WeBWorK could have different or opposite effects across course sections, which were taught at different times and by two different instructors. Generally, the type of homework used did not demonstrate any significant effects. The same conclusion can be drawn when comparing course sections regardless of homework type.

In the model, homework type, course section, and the interactions between homework type and course section were fixed effects and other factors such as quiz topic and individual students were random. The model was supported by an analysis of deviance.

The use of WeBWorK across all sections was compared with the use of traditional homework and the quiz scores from sections 002 and 003 were compared with 001 regardless of homework type. The interaction between the use of WeBWorK and section 002 and WeBWorK and section 003 were compared with the use of traditional homework in section 001. The p-values in **Table 2** showed that positive (yet insignificant) effects were observed in all comparable cases except when observing the interaction between the use of WeBWorK in section 003 (p-value=0.042). The use of WeBWorK in section 003 resulted in a significant decrease in quiz scores.

The odds ratios shown in **Table 2** show that, in general, when switching to WeBWorK from traditional homework the odds of students performing better on the quiz is +3.4% (an insignificant increase). However, only in section 003 did the use of WeBWorK decrease the odds by 11.1% (a significant decrease).

**Table 2. Z-scores and odds ratios by homework type and course section. (WW = WeBWorK)**

| Assessment | Estimate | Standard Error | z-value | Pr(>\|z\|) | Odds ratio |
|---|---|---|---|---|---|
| **Type WW** | 0.0336 | 0.0379 | 0.886 | 0.3756 | 1.0341 |
| **Section 002** | 0.1310 | 0.1772 | 0.739 | 0.4597 | 1.1400 |
| **Section 003** | 0.0317 | 0.2016 | 0.157 | 0.8752 | 1.0322 |
| **Type WW: section 002** | 0.0125 | 0.0492 | 0.255 | 0.7989 | 1.0126 |
| **Type WW: section 003** | -0.1178 | 0.0579 | -2.033 | **0.0421** | 0.8889 |

Explaining why section 003 showed a significant decrease while the other sections showed small increases is very difficult, but the authors have proposed a few possible explanations. Section 003 is taught by instructor IA who also teaches section 001, so the authors feel confident that the instructor or his methods did not contribute significantly to the observed decrease. Section 003 is the only section taught in the afternoon (2:30 – 4:20 PM). There has been studies and similar reports at other universities that show that students who take classes in the afternoon significantly underperform [12]. As the authors have observed in other courses, this time can affect student performance due to a number of reasons. Because the class starts after the typical lunch break for most students, students who may have eaten a meal right before class could be lethargic and tired which would affect their performance on the quiz. The class is also during one of the hottest parts of the day, and in the humid South in the spring this could also make students tired and sluggish. A third and possible factor is an imposed time constraint that might have affected the afternoon section more than the morning sections. To facilitate assigning the homework, all three sections were assigned the homework at the same time. To prevent students from working on homework after the start of the section 001 class (at 8:00 AM), the homework submission link was closed for all students regardless of class section. Despite the fact that all class sections were given at least two full nights to complete the homework, it is highly possible that some of the students in the afternoon section 003 class waited to attempt or complete their homework until the morning before class. Though students could still look at the homework after

the submission link expired, it is believed most would ignore the problems if no credit would be gained by working on them. Students were warned of the dates and times that homework was due, but it is possible that students ignored or forgot the warnings.

**Student Survey Results**

Online surveys were administered to the class at the beginning of the course and at the end of the course to evaluate student perceptions of the use of WeBWorK in their studies. In general students showed little to no change regarding identity and self-confidence before and after the course (a similar outcome that was also noted in the other sophomore engineering courses [2] [3]). Students generally felt comfortable about their choice of engineering major and the prospects of having a fulfilling career in engineering. At the end of the course, students were asked to rate their level of agreement on additional questions regarding their use of WeBWorK and their feelings on the use of WeBWorK as a homework tool in their thermodynamics course. The survey showed that 17% of students who completed the survey (n = 23) had no experience with WeBWorK prior to taking the thermodynamics course. Students who reported having early exposure to WeBWorK identified the use of WeBWorK in the mathematics courses and in engineering Circuits (ENGR 221) and engineering Statics and Mechanics of Materials (ENGR 220). The survey polled students regarding the amount of time per week students dedicated to working on homework and found that 83% said they spend 2-8 hours per week doing homework; the remaining 17% reported spending more than 10 hours per week doing homework. **Table 3** shows the percentage of students who agreed or strongly agreed with the effectiveness of WeBWorK.

The collected survey results showed that students unanimously agreed that the instant feedback feature of WeBWorK is very useful, but only 57% of students said that the gained feedback was more useful than the feedback that may be received from a grader looking through the homework. A majority of students agreed that the easy access to contacting the instructor and the relatively quick grade calculations were also favorable features. In general, the use of WeBWorK did not significantly decrease group discussion among students (though each individual student would receive a unique problem statement) and only 39% of students though the WeBWorK problems were more challenging than standard textbook problems (whether more difficult questions are seen as advantageous or not by students is difficult to ascertain).

Negative views of WeBWorK were also evaluated from the survey as shown in **Table 4**. Only one or two students out of the group that responded to the survey found that WeBWorK was too difficult to use for homework. The biggest complaint students offered was disagreement between students and WeBWorK regarding correct answers. There were a few minor errors in the WeBWorK programming when it first rolled out, but nearly all of those problems were fixed within the first few days of the start of the course. Another explanation for the disagreement may arise from the slightly different teaching styles and methods between the course instructors and the instructor (who was not a part of the study) who created the original problems. Differences in choosing appropriate equations between the two instructors could cause some problems to be marked wrong on WeBWorK while otherwise being correct according to the styles presented in class. Though equations and variables in the program can easily be changed by instructors, the

implementation of property tables for various substances (e.g. water, air, R-134a, etc.) into the program is cumbersome and difficult to do in a short period of time.

**Table 3. Student survey results of perceived efficiency of WeBWorK.**

| Statement | % of students who Agreed or Strongly Agreed (n = 23) |
|---|---|
| My previous experience with WeBWorK was positive. | 79% **(*n = 19)** |
| I am more comfortable using WeBWorK to submit my homework than writing my homework out by hand and submitting it to the professor. | 83% |
| I believe that I will make better grades in this class because I have used WeBWorK for homework submission as opposed to or in addition to other methods. | 57% |
| I prefer WeBWorK compared to other methods of homework submission. | 65% |
| As a whole, WeBWorK problems are more challenging than problems out of a textbook. | 39% |
| The addition of WeBWorK assignments better prepare me for course examinations than only pencil and paper homework. | 61% |
| Email access to my professor is a useful component of WeBWorK. | 87% |
| I like that WeBWorK lets me know immediately if my answer is correct. | 100% |
| I have found that the feedback I get from WeBWorK is more useful for learning how to work problems than the feedback I get from written homework submissions. | 57% |
| I get more out of this class because I submit my homework via WeBWorK. | 48% |
| I typically work on WeBWorK together with a group of engineering students. | 61% |
| I prefer WeBWorK compared to other homework submission methods because I know my homework has been graded and will count toward my grade, whereas in some cases with written homework submissions, the professor may not grade my homework. | 78% |

**Table 4. Student survey results regarding negative feelings about WeBWorK.**

| Statement | % of students who Agreed or Strongly Agreed (n = 23) |
|---|---|
| I do not like using WeBWorK because I find it too difficult to submit my homework answers electronically. | 9% |
| As a whole, WeBWorK problems are more challenging than problems out of a textbook. | 39% |
| I do not like using WeBWorK because I've had difficulty using the program. | 4% |
| I do not like using WeBWorK because, although I entered the correct answer, it still said my solution was incorrect. | 30% |
| I often get frustrated with WeBWorK and give up on a problem due to the difficulty of the assigned homework problem. | 27% |

## Conclusions and Future Work

The purpose of this study is to identify the effects on student performance in a thermodynamics course caused by the use of WeBWorK as an online homework delivery tool instead of traditional paper or book homework. Thermodynamic problems have been created for the open-source system as part of a NSF-funded project. The purpose of the project was to expand the use of WeBWorK into sophomore-level engineering courses and study the effect of these online problems on student learning. The use of WeBWorK has already been implemented in

mathematics courses and engineering statics and circuits courses at Louisiana Tech University. Student feedback has shown that students generally have positive views regarding the use of WeBWorK specifically citing the instant feedback that students receive when they submit their answers. The authors and other instructors at our institution who use WeBWorK also find the system beneficial for instructors due to the instant feedback and the ability to streamline the homework assigning and grading processes.

In this study, class sections were divided into two test groups: one group was assigned WeBWorK and the other group was assigned the same problems using traditional paper homework. Quizzes were administered to both groups at the start of class when the assignments were due; these quizzes were used to evaluate student understanding on selected thermodynamic topics and identify any effects caused by the type of homework assigned. A statistical analysis on the first set of limited data shows that the use of WeBWorK generally does not significantly affect student performance. The use of WeBWorK in an afternoon section of the course did display a significant decrease in quiz scores, but the authors believe there may be underlying factors that could have caused the observed decrease. Because the general trend shows that assigning WeBWorK does not hurt student performance, the authors recommend the use of WeBWorK as an effective tool to at least assist instructors who may be facing a reduction or shortage in available resources for supplementing engineering instruction.

Work is underway for the current academic year. In addition to expanding the sample size, the format of the quizzes has undergone some changes. It was suggested that a portion of the quizzes strongly reflect student understanding of concepts as opposed to just application of the concepts. New quizzes include concept inventory questions for the classes being studied. The quizzes used for the study reported here were modeled after the homework and shortened so students could complete them in the limited time allotted at the beginning of class. The use of a multiple choice format is being used to remove the need of an independent grader and to remove any biases that may exist when assigning partial credit. For the reported study, quizzes made up a small portion (5%) of the students' final grades. Some of these students may not have taken the quizzes seriously (as evident by some absences), thus lowering the population size and possibly artificially lowering student performance. There has been an ongoing discussion to either increase the weight of the quizzes or to offer extra credit as a possible way to increase student participation.

**References**


[1] K. Evans and P. Hummel, "Assessing the Effect of Online Homework on Student Learning in a First Circuits Course," in *American Society for Engineering Education Annual Conference and Exposition*, Seattle, 2015.

[2] K. Evans, P. Hummel and M. Gates, "An Expanded Study to Assess the Effect of Online Homework on Student Learning in a First Circuits Course," in *American Society for Engineering Education Annual Conference and Exposition*, New Orleans, 2016.

[3] M. K. Swanbom, D. W. Moller, K. Evans and T. Reeves, "Open-source, Online Homework for Statics and Mechanics of Materials Using WeBWorK: Assessing Effects on Student Learning," in *American Society for Engineering Education Annual Conference and Exposition*, New Orleans, 2016.

[4] D. Doorn, S. Janssen and M. O'Brien, "Student Attitudes and Approaches to Online Homework," *International Journal for the Scholarship of Teaching and Learning,* vol. 4, no. 1, 2010.

[5] R. L. Bangert-Drowns, C.-L. C. Kulik, J. A. Kulik and M. Morgan, "The Instructional Effect of Feedback in Test-like Events," *Review of Educational Research,* vol. 61, no. 2, pp. 213-238, 1991.

[6] D. M. Nguyen, Y.-C. Hsieh and G. D. Allen, "The Impact of Web-based Assessment and Practice on Students' Mathematics Learning Attitudes," *Journal of Computers in Mathematics and Science Teaching,* vol. 25, no. 3, pp. 251-279, 2006.

[7] J. P. Carpenter and B. D. Camp, "Using a Web-based Homework System to Improve Accountability and Mastery in Calculus," in *American Society for Engineering Education Annual Conference and Exposition*, Pittsburgh, 2008.

[8] D. S. Brewer, *The Effects of Online Homework on Achievement and Self-efficacy of College Algebra Students*, Logan, UT: Utah State University, 2009.

[9] W. Ziemer, "WeBWorK: An Open-source Online Homework System," in *Invention and Impact: Building Excelence in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Education*, American Association for the Advancement of Science, 2004, pp. 169-171.

[10] H. L. and C. Weibel, "Statistical Evidence that Web-based Homework Helps," *MAA Focus,* vol. 23, no. 2, p. 14, 2003.

[11] R. J. Marzano, P. D. J. and J. Pollock, Classroom Instruction that Works: Research-based Strategies for Increasing Student Achievement, Alexandria, VA: Association for Supervision and Curriculum Development, 2001.

[12] S. K. Kantartzi, S. Allen, K. Lodhi, R. L. Grier and M. A. Kassem, "Study of Factors Affecting Students' Performance in Three Science Classes: General Biology, Botany, and Microbiology ay Fayetteville State University," *KBM Journal of Science Education,* vol. 1, no. 1, pp. 13-18, 2010.

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