Comparison of Students' Performance Using Web-Based and Paper-Based Homework in an Undergraduate Statistics Course

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Abstract
Our institution is heavily invested in improving the learning outcomes of our students, especially in core courses like statistics which is taken by majority of freshmen students. As such, we have been reviewing our existing pedagogy and exploring novel ways to improve students experience in statistics course. In this study we compare web-based vs paper-based traditional homework models and their impact on students' performance in an undergraduate statistics course. In web-based model, students used MyStatLab to complete the homework assignments along with additional resources offered by this platform. On the other hand, in paper-based model students used traditional approach in completing the homework and was manually graded by the instructor. Our analysis indicated that there is no statistically significant difference in students' final course grades between the two modalities. Additionally, we conducted a chi-square test of independence and found no statistically significant relationship between students' final course grades and homework models. However, our analysis concluded that student performance and perceptions improved with online homework model compared to the traditional model.

1. Introduction

In recent years, web-based online homework assignments have been replacing the traditional ones with the help of technology (Serhan, 2019) and this practice became quite common during the pandemic era. Although strong investment has been made to enable schools and colleges to achieve this transformation, a literature review shows that only a few studies have measured the impact of online homework on students' performance especially in statistics. In general, the effects of the homework formats on students' performance have been reported with mixed results (Magalhães et al, 2020). One of the earlier studies (Palocsay & Stevens 2008) reported that the delivery modes of homework make little difference in student performance but it is hugely improved by teacher experience and student academic proficiency. Similarly, another study by Bromberg and Seminelli (n.d) who investigated the effect of web-based versus paper-based quizzes on student performance in a freshman level mathematics course found no difference. On the other hand, a meta-analysis of a comprehensive study of the efficacy of computer-assisted instruction (CAI) conducted by Larwin & Larwin (2011) on student success in college statistics education suggested that the typical student moved from the 50th percentile to the 73rd percentile when technology was used in the curriculum. Another study (Jonsdottir et al, 2017) revealed that a web-based homework had a positive impact on students learning in an introductory statistics course.

Saleh et al (2022) describes the process of remote assessment in medical education during the COVID-19 lockdown showed the similarity between students' results for web-based and paper-based examinations, both on class average and for individual students' scores and concluded that web-based examinations are an ideal approach for formative assessment, progress testing, and frequent low-weight continuous assessment such as homework.

In the early phase of online homework, some researchers (Wooten & Dillard-Eggers, 2013) suggested that online homework is one option to motivate students to increase their effort in the course and may be very beneficial for the less motivated, poorer performing students. However, individual differences among students and different learning styles must be considered. It also concluded that no one study tool will be best for all students or in all situations. Brewer (2009) found more students with low incoming skill levels and more repeating students received a passing grade when using online homework than did their higher-skilled, first-time counterparts and concluded that online homework may be even more effective for helping the large population of students who enroll in the math course with inadequate prerequisite math skills. The motivation for our current study arises from the fact that subject specific analysis on this topic has been largely missing in current literature. Thus the goal of this study is to conduct a systematic investigation of measuring the impact of web-based online homework compared to paper-based traditional homework in an undergraduate statistics course at our institution.

Regis is a small catholic university located in the suburb of Boston, which provides academically rigorous education with offerings in the schools of nursing, arts and sciences, business and communication, and health

sciences education to about 3,600 undergraduate, graduate, and doctoral students. Regis's top priority is the success of its students. At Regis, freshmen students are supported through a First-Year Experience which includes various activities based on curriculum and co-curriculum contents. The core curriculum focuses on providing students with the Essential Learning Outcomes in accordance with the Association of American Colleges and Universities (AACU, n.d.) and is in line with the mission of our founders, the Sisters of St. Joseph of Boston, and the catholic intellectual tradition.

In 2016, Regis received a prestigious federal Title III grant to enhance student support services in order to strengthen the academic quality. To improve student learning outcomes through the Title III grant, Statistics course (MA 210) has been identified as one of the courses impacting a high proportion of students and known to be a stumbling blocks for many students. It contains skills that serve as prerequisites for subsequent courses. Some of the goals of this grant was to focus on embedding AAC&U High Impact Practices (AACU, 2022), developing toolkits that enable students to utilize the resources effectively, incorporating related adaptive learning techniques, and delivering professional development in highly-enrolled courses like statistics.

Regis improved the mathematics education by introducing several changes in the curriculum and its delivery methods. For example, corequsite model was introduced in 2014 where students enrolled simultaneously in a credit-bearing math course and a course that provided remediation (Kashyap & Mathew, 2017). We employed adaptive technology in introductory math courses where students used competency based adaptive platform to master the content by learning the material at their own pace, then practicing the problems and finally getting certified on their homework assignments (Mathew & Kashyap, 2019). As practiced in many colleges and universities across the country, faculty at Regis introduced web-based homework technology in statistics course (MA 210) in 2018, which is taken by majority of freshman students. Prior to this technology, we used a traditional approach in teaching this course. It was primarily a lecture-based system with students completing their homework on paper and manually graded by instructor. Often instructors take a few days to complete the grading during which a student might reinforce incorrect concepts that hinders their learning of the subsequent topics. Also, this was a waste of time for both the instructor and the student as the technology could eliminate the manual grading.

Web-based homework in introductory math courses offers a number of benefits to students and instructors. It provides instant feedback, reduce the grading burden on faculty and provides access to online textbook. This can also help to identify those students that are quietly struggling with concepts but are afraid to ask. Although, it may not be able to provide detailed feedback, web-based homework systems deliver fairly standard materials and exercises, changing the delivery medium without altering the pedagogical content (MAA, n.d.).

2. Background

Regis offers MA 210 as an introductory level statistics course through its STEM department. Topics covered in this course are descriptive methods of statistics, probability, normal distributions, estimates and sample sizes (confidence intervals), hypothesis tests, analysis of variance, chi-square test of independence and correlation and regression, with an emphasis on applications. Further, students gain the ability to use and interpret the p-value as it occurs in research and journal publications along with the ability to use SPSS (formerly known as the Statistical Package for the Social Sciences) to both create and interpret results of statistical analyses. Students in this course learn to apply mathematical information, concepts and thoughts in verbal, numeric, graphical and symbolic form to solve different types of problems as part of the mathematics core curriculum requirement with the following student learning outcomes (regiscollege.edu).

2.1 Student Learning Outcomes SLOs:
1. Evaluation of types of data and appropriate summary statistics
2. Apply, analyze, and interpret various types of hypothesis testing
3. Use SPSS to assist in specific types of hypothesis testing
4. Understand the p-value and apply it to decision-making
5. Understanding and remembering the above information, particularly the p-value interpretations, when reading professional research articles in the future

At Regis, the MA 210 is offered as a one-semester statistics course unlike many other institutions that offer this course in a two-semester sequence. As such, many students felt this course was intense and fast-paced. They expressed concerns about rushing through the materials especially towards the end of the semester. For example, correlation and regression analysis are taught almost at the end of the semester although these are very significant part of the syllabus and require more time to completely comprehend it. Students felt they didn't have enough time to utilize all available resources and instructional support to master these topics.

The above concerns prompted us to explore the possibility of altering the paper-based homework with online homework as it provides, as stated earlier, many benefits to students that include immediate feedback on problems and the opportunity for them to attempt exercises multiple times. It also helps the instructor to reduce

the grading time which could be utilized for supporting students in more meaningful ways. It also provides pedagogical support to enhance the student learning experiences. For example, it offers adaptive learning skill building exercises. Each question in these exercises are based on students' responses to the previous questions. It also offers assignments that allow a student to work through a problem step-by-step and receive immediate feedback at each step (MAA, n.d.).

Another advantage of using web-based homework is that it provides analytics useful for tracking students' progress in the course which would have been much difficult to achieve with paper-based system. It tracks student performance data (e.g. how much time student is spending on learning material and practicing problems before completing the assignment) that can help us identify underperforming students. Our institution takes a proactive approach in identifying and supporting at-risk students. At Regis, we use Starfish (Starfish, 2022), which is an online advising and retention management tool to raise flags to alert concerned parties when a student is not meeting the course expectations or performances. At many instances, majority of the at-risk students could be identified early in the semester as there is a relation between academic procrastinations through late homework/non-submission and student performance (Akram et al, 2019). Furthermore, it helps theses students successfully completing their course as reported in a study indicating that at-risk students' use of a learning analytics platform is associated with earning a final passing grade (Russell et al, 2020).

3. Method of Study

In order to conduct this study, we collected data from 106 students who took statistics course at Regis from fall 2016 to spring 2022. There were seven sections of this course that were taught by the same instructor. All courses utilized a common syllabus, grading policy, academic resources and support. The instructor created tests, quizzes and homework assignments identical in content and difficulty level. The online homework was assigned for every topic completed in the class and students were required to finish the assignments before the following class. Instructor proctored the test and quizzes in-person throughout the semester. The final course grade was based on following components of the coursework: quizzes (15 percent), three tests (45 percent), homework (15 percent), attendance and class participation (5 percent) and the final exam (20 percent).

Among the above students, 48 of them were enrolled in three different statistics course sections from fall 2016 to fall 2017 before we rolled out the online homework platform. The textbook used for this course was "Understandable Statistics" by Brase and Brase (2014) published by Cengage Learning. The students in this group completed their homework assignments using paper and pencil. The homework assignments were collected and graded manually. The graded homework was scheduled as needed throughout the course. Assignments were to be turned in on the due date and late assignments were not accepted. Students used SPSS statistical software for analyzing data during the course of study.

The remaining 58 students from the sample were enrolled between fall 2018 and spring 2022 in four different sections of the course. The textbook used for this group was "Elementary Statistics", by Triola, Published by Pearson Education (2012). These students completed their online homework assignments using the MyStatLab adaptive technology. MyStatLab which is Pearson's MyMathLab equivalent in statistics, contains videos, quizzes, and homework assignments. Problems for these assignments were selected from course textbook instead of importing from external sources. It also offered adaptive learning skill building exercises as each question in a skill building exercise is based on the student's previous answers. Additionally, workspace assignments allowed a student to work through an exercise step-by-step and receive immediate feedback at each step. Homework assignments were completed online with MyStatLab and had been scheduled throughout the course. These assignments were completed in the time frame assigned and were not be available after that. Along with SPSS, students also had access to StatCrunch for analyzing data. StatCrunch is a web-based statistical software application from Pearson and is part of the MyStatLab package.

We used the student class average score as indicator of the success in this course. In order to identify how the modality of homework assignments would have impacted the student performance in statistics courses, we compared the class average for each of these groups. At Regis, C- (C minus) is the minimum grade needed to proceed to any higher level math courses. Therefore we examined the data for the students in these categories (C- or above and D+ or below) as well. We performed a chi-square test to find out whether this association between the homework models and the grade earned (pass/fail) is statistically significant.

4. Results and Discussion

The results of this study are given in Table 1 and 2. To analyze the difference, we compared the academic performances of these two groups of students (paper-based homework vs. web-based homework). As mentioned above, one group used paper-pencil homework and the other group used web-based MyStatLab homework. Students in both groups had similar academic profile (majority of students were non-science majors) taking this course to fulfill general education core requirements in mathematics. All the assignments and the performance measures including the students learning outcomes were the same for both groups. We gathered both qualitative

and quantitative data from students to assess their performance and experiences in these courses. We analyzed our data using the statistical software StatCrunch available with MyStatLab package.

As stated above, we compared the performance of students from both groups. For each of these groups, the sample size, mean and standard deviation of the final course grades are displayed in Table 1. Then we performed hypothesis testing using independent sample t-test to compare the means of the final course grades for both groups. Null hypothesis stated that both means are the same and alternate hypothesis stated that they are different. Out test result: t- test statistic t = 1.98, p-value = 0.0508. Because p-value > 0.05, we failed to reject the null hypothesis. Based on this test, we concluded that there is not statistical significant difference between the two means.

Table 1. Grade Comparison of students with traditional HW vs. Online HW

HW Models	Sample Size	Mean of Final Grade	Std. Dev. Of Final Grade	Std. Error	P-value
Traditional	48	75.41	18.84	2.72	0.0508
Online	58	82.61	18.46	2.42	

Hypothesis test results

Difference	Sample Diff.	Std. Err.	DF	T-Stat	P-value
$\mu_1 - \mu_2$	-7.2009	3.6428	99.5439	-1.9767	0.0508

Table 2 displays the contingency table and chi-square test result for the two categories of students. We counted the number of students who earned C- or above (passing grade) and the number of students who received D+ or below (failing grade) in each of these two categories. We performed a chi-square test to find out whether the association between the homework models and the grade earned (pass/fail) is statistically significant. The results of the chi-square test given in Table 2 suggest that these variables are independent.

Table 2. Contingency table and Chi-Square Test results

HW Models	C-or above	D+ or below	Total
Online	48	10	58
Traditional	37	11	48
Total	85	21	106

Chi-Square test

Statistic	DF	Value	P-value
Chi-square	1	0.53249139	0.4656

4.1 Students Perceptions

As part of this study, we surveyed students in both modalities to solicit feedback about the course materials and instructional methods. This qualitative survey enabled us to measure overall efficacy of the two different modalities of homework we followed during the years 2016 to 2022. Students were asked to provide feedback on the various aspects of the homework including organization, difficulty of problems and the level of comprehension they would achieve after completing it. This also helped us to gauge student's perceptions and perspectives about these two modalities.

Our analysis of the survey results concluded a marked advantage for the web-based homework over the paper-based one. While 60% of the students who used paper-based homework reported overall satisfaction, almost 80% percent of the students expressed same level of satisfaction with online homework and its linked resources. Most of the students expressed the view that the instant feedback they received from the web-based homework platform was quite beneficial in comprehending the course topics covered in the class and reported that it played a crucial role to their success in the course. However, students in the other group often expressed frustration over the waiting time to receive their graded homework back which hindered their performance in the course. Additionally, the use of adaptive technology employed in web-based homework enabled the students to practice more problems while attempting the homework. Overall, with online homework students' enthusiasm was high and they explored the course material with self-motivation and renewed determination.

Furthermore, in open-ended responses part of the survey students noted several advantages of online homework that include systematic organization of problems, the instant access to online textbook when they needed and the availability of other resources like video lessons. It is to be noted here that the instructor made every effort to customize the assignments to cater to the needs of our student population majoring in various disciplines. For the initial implementation of online homework, this amounts to at least an additional hour of work per week from the instructor compared to the paper-based model. However, as mentioned in the introduction instructor was able to save time from   grading the homework manually and used it for supporting struggling students as identified by the analytical report. We list some of the feedbacks received from the survey below:

Web-based online homework

1. MyStatLab allowed me to do the work at my own pace and the online resources made me successful.
2. The adaptive study plan provided within MyStatLab was essential to my success in this course.
3. The online homework is easy to navigate and very helpful and it correlates with topics taught in class.
4. Doing homework problems on MyStatLab really strengthened my understanding of the course materials.
5. "Help me solve this" and "show me an example" allowed me to understand the material in real time.
Traditional Homework
6. The homework would have been graded a little earlier and the material in class were rushed. I would like to receive the feedback on graded assignments back a little earlier to fully understand what I needed to improve on.
7. By assigning more homework problems so we can understand the concepts. It's easy to lose attention in what's going on and become lost.
8. More explanation and interactive help on homework. Some of the questions we never went over in class so it was hard to learn on its own.

A limitation of this study was due to the fact that multiple submissions were allowed to students in the online homework, which might have skewed our data to identify the level of learning difficulties met by individual students. Also, students often approach homework without adequate preparation since there are unlimited tries available within online homework and this might have reduced their effort to solve the assigned homework problems.

5. Conclusion

This study did not find any statistically significant difference between the performances of students in both modalities. However, the students' enthusiasm as reflected in the above feedbacks reveal that online homework could be a valuable asset in teaching and learning statistics. The fact that students were able to get considerable feedback and support from online homework without compromising their performance or quality of learning is a huge advantage over traditional homework. Additionally, the instructor had much more flexibility in engaging the students pedagogically in the homework assignments using the adaptive technology along with the ease of choosing problems from the vast pool of questions provided by the online platform. To facilitate the effective use of online homework, the instructors should invest a considerable amount of time in choosing and assigning the problems that fulfil the student needs and level of competency. However, once the homework is assigned to one section it can easily be imported to other sections or even in the following semesters with minimum effort. As a result, the saved time could be utilized for identifying the struggling students early in the semester using the data analytics provided by the online homework platform. While we acknowledge that online homework may further impersonalize the learning process, carefully chosen homework problems that supplements classroom instruction would be both beneficial to students and instructors to accelerate the learning process. Nonetheless, instructor must utilize the student performance data analytics   provided by MyStatLab regularly to identify and support struggling students in order to reap the benefits stated. Also, students should be convinced that that homework completion is essential for learning and academic growth, rather than to be completed as quickly as possible to finish the course. Furthermore, we recommend extensive studies to evaluate students' performance in specific subject areas within mathematics like algebra and calculus using web-based and paper-based homework models. This will enable instructors and institutions to follow an integrative approach in adopting customizable web-based homework models that fit the needs of their student population.

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