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A Comparison between Blended and Online Teaching Method for Statics Course: a perspective in a Community College

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A Comparison Between Blended and Online Teaching Method for Statics Course: A Perspective in a Community College

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Abstract

Many colleges decided to go online for the Spring 2020 following the restriction from the government to have in-person classes due to the COVID-19 pandemic. This study investigates the effectiveness of online teaching for a Statics course compared to blended teaching methods using results of a concept inventory (Concept Assessment Tool for Statics, CATS) test. These results were taken from students (11 – 20 students on each observed group) attending Tacoma Community College before and during the pandemic. Two hypotheses are tested this study: 1) to reject the null hypothesis that there is no significant difference between students' performance in online class at the beginning and at the end of the quarter, and 2) to accept the null hypothesis that there is no significant difference on the test results between students in blended and online class. The results of the hypotheses testing reject the first null hypothesis and accept the second null hypothesis. These results suggest that online teaching can be as effective as the blended teaching for a Statics course within the scope of this study.

Keywords

online learning, blended teaching method, community college, Statics, teaching method comparison

Introduction

Statics is one of the gateway courses for many engineering students, especially those majoring in Aerospace, Civil and Mechanical Engineering. Many students take this course in their second year, and it is often a required course for their second application to the specific majors within their universities or for transferring to four-year universities for community college students.

Similar to many other courses, different instructors have different perspectives or opinions on how a course should be delivered. However, this is not the case when the COVID-19 pandemic hit. The majority of college instructors were required to make a sudden shift to online teaching. This included those who taught this Statics course in two-year community colleges.

This study investigates students' performance in a Statics course in Tacoma Community College (TCC) before (Quarter 1) and during (Quarter 2 and Quarter 3) the pandemic taught by the first author of this paper. Prior to the pandemic, this course was taught in blended teaching method and during the pandemic, it was taught in an asynchronous online method. Concept Assessment Tool for Statics (CATS) was used to measure students' performance in those three independent quarters. Comparisons were made to the results of the test and analyses are conducted to investigate two hypotheses: 1) to reject the null hypothesis that there is no significant difference between students' performance in online class at the beginning and at the end of the quarter, and 2) to accept the null hypothesis that there is no significant difference on the test results between students in blended and online class.

Blended teaching method

Margulieux et al.[1] stated that blended learning includes a substantial portion of teaching methods from both delivery media (i.e., instructor and technology) and both instruction types (i.e., information transmission and praxis). This definition was proposed to avoid confusion of multiple terms (i.e., flipped, inverted, blended) that described a similar teaching method. Blended teaching methods have been applied in Statics courses by many instructors. Papadoupoulos and Roman[2] applied what they called as inverted classroom model in Statics class. In this model, pre-lecture online modules were shared with students and to be completed prior to lecture. Lectures were focused on discussion and activities built upon the materials introduced in the pre-lecture modules. The final component in this model is post-lecture problem solving sessions. Maalouf and Putzeys[3] mixed traditional classroom lectures, pre-recorded video lectures and activity sessions together. Holdhusen[4] and Sangree[5] combined pre-recorded video lectures that needs to be watched prior to attending class sessions to complete active learning exercises.

For the blended teaching method considered in this project, the instructor provides 57 pre-recorded videos uploaded to a learning management system (LMS). These videos discuss concepts, derivations, and walk-through solutions to some fundamental example problems. The average duration of the videos is 13 mins, with the maximum duration of approximately 22 mins, and minimum duration of approximately 4 mins (See Table 1). The longer duration videos are often related to example problem discussions. The videos were not scripted but outlines were decided prior to recording the videos. The videos were recorded by capturing screen of a tablet computer and instructor upper body. Therefore, students watch not only what the instructor wrote down on the tablet but also see instructor's facial expression, body language, and physical demonstration tools used to describe some concepts in Statics.

Table 1 Types of videos and their durations assigned on the student groups

	Blended (Qtr 1)	**Online (Qtr 2)**	**Online (Qtr 3)**
Total number of the pre-recorded videos	57	71	
Average durations of the pre-recorded videos (minutes)	13:00	13:01	
Maximum durations of the pre-recorded videos (minutes)	22:31	22:51	
Minimum durations of the pre-recorded videos (minutes)	04:32	04:32	
Total number/ average durations (minutes) of the pre-recorded problem-solving videos	24/ 14:20	37/ 14:04	
Total number/ average durations (minutes) of the pre-recorded conceptual videos	33/ 12:03	34/ 12:12*	
Total durations of online live problem-solving session videos (minutes)	N/A	352	754**

* The difference on the average duration is caused by rerecording of some conceptual videos.
** New online live problem-solving videos recorded throughout quarter 3 was 352 minutes. Students were also given the access to the recorded online live problem-solving videos from quarter 2.

After watching the pre-recorded videos on a specific topic, students were required to complete a short conceptual quiz with some multiple choice or true/false questions to check their understanding on concepts explained in the videos. Students obtained automatic feedback set in the LMS as they completed the quiz. Students were expected to watch these videos prior to coming to class. In the classroom, the instructor summarized important concepts or lead a class discussion or problem-solving session before letting students solve problems on their own or with their classmates. This blended method enables instructors to provide direct instruction often necessary for difficult topics and at the same time enable instructors to troubleshoot students' confusion on the spot as they work on the problems.

Asynchronous online teaching method

Initial efforts to design an online Statics class had been done by some instructors prior to the COVID-19 Pandemic[6,7,8]. Dollar and Steif[6] designed a web-based Statics course with multiple engaging components, such as simulations and exercises, to help students understanding and assessing concepts they have learned. Sorby and Vilmann[7] built upon the web-based Statics course developed by Dollar and Steif[6] and added a small portion of in-person meeting to cover topics that are not available in a web-based format. Howard and Stimpson[8] converted their flipped Statics class into fully online. In the fully online format, students have the same access to all digital materials that the flipped class provided. They did not participate in the in-person session to work in a team on the Statics problems. However, they were able to view videos of these in-person sessions and encouraged to solve the statics problems themselves.

Some literatures have discussed the transition to an online Statics class either from traditional-lecture format or the flipped class format during the pandemic. Richards[9] converted the traditional lecture format class into fully online and compared students' performance between ones exposed to fully in-person and ones exposed to fully remote learnings. Sangree[5] converted the flipped statics course into online format. Students in online format had the same access to the materials in the flipped class administered prior to the COVID-19 pandemic. The only difference is that the class sessions to solve Statics problems were conducted in online break out rooms instead of in-person.

According to its meeting time, online teaching can be divided into synchronous and asynchronous formats. In the synchronous format, students will meet with instructor in an online video conference platform at specific time frames, and teaching and learning activities between instructor and students will occur at those time frames. On the other hand, in an asynchronous format, there is no specific time where instructor meet all students in video conference platform to engage in teaching and learning activities. Students have their own flexibility to access various learning materials provided by instructor at their own schedule. However, there may still be a specific office hour time that students can meet virtually with instructor to address some questions pertaining course materials.

Asynchronous online teaching method is the format considered in this study. Students have flexibility in watching pre-recorded lecture videos. These are almost the same videos students watched in the blended teaching method. One new video was added and 6 out of 33 conceptual videos were pre-recorded to enhance their clarity. The missing in-class interactions from the blended learning were replaced by more additional problem-solving videos (total 13 videos, average durations 13:36 minutes, see Table 1) pre-recorded by the instructor. In addition, the instructor held online live weekly problem-solving sessions in which students met for an hour in a video conference platform to solve Statics problems and to answer students' questions pertaining concepts they have learned on their own. These online meetings were recorded so that students who could not attend could watch the videos and students who attend the meeting could review the discussions. A total of 352 minutes online live problem-solving videos was recorded in Quarter 2, and approximately the same number of minutes was also recorded in Quarter 3. However, students in Quarter 3 were also given the access to the live problem-solving videos recorded in Quarter 2. These live sessions were one of the means to engage students in online learning. The other components, such as homework and exams, remained the same as the blended teaching method.

Definition of Statics at Tacoma Community College

At TCC, Statics is a 5-credit course taken by students who completed a calculus-based physics (mechanics) and calculus series courses as pre-requisite. The course covers various topics, such as force vector, moments and their resultant, 2D and 3D equilibrium of rigid bodies and their structural application, shear and bending moment diagrams, dry friction, and centroid and moment of inertia. TCC adopts a quarter system, so this course meets 5 times (each 50 minutes) a week in a regular academic year (e.g., pre Covid-19 pandemic). A full-time student at TCC will need to take 15 credits each quarter.

Personal and Social Experiences of Engineering Students in Community Colleges

Knight, et. al.[10] conducted an interesting study on characteristics of two-year institutions engineering students. This study reported that students in community colleges tend to spend significantly less time for academic activities than non-academic activities, such as working for pay, family responsibility, and commuting to/from campus or workplace. It is also reported that the average age at enrollment for community college is 22.4 years. Although no students' demographic, personal and social experiences data were collected in this study, the authors of this paper feel the above descriptions roughly described the demographic, personal, and social experiences of engineering students in Tacoma Community College. From the interaction between the first author and his students in Statics, many of students work part-time or full-time on top of being a full-time or part time-student.

Concept Assessment Tools for Statics (CATS)

CATS is an inventory of Statics problems developed by Steif and Dantzler[11]. This inventory was developed to improve students' learning in various ways. Since its development, many researchers have adopted this tool to get feedback from students on their understanding of important Statics concepts, including using this tool as an objective way to quantitatively compare students' performance exposed from various teaching methods in Statics. The test consists of 27 questions addressing important concepts in Statics, such as freebody diagrams, equilibrium, forces in connectors, dry friction and static equivalency of force systems. It should be noted that all of these questions only cover the 2D geometrical aspects of Statics problems. Students taking this test fill out an anonymous consent form whether they agree that their results will be used for research study.

Methodology

Students' CATS data from three independent student groups from three quarters were collected and analyzed. The first group of students was exposed to blended teaching method (Quarter 1) and the second and third groups were exposed to asynchronous online teaching method (Quarter 2 and 3). It is a fair assumption to be made that the three groups of students at least have the same minimum amount of knowledge on Physics and Calculus when enrolling in this course as these are the pre-requisites for Statics. However, no information was collected regarding student's academic performance (e.g., GPA).

Based on the collected CATS data, general statistical analyses were conducted and then two hypotheses were tested.

1) There is no significant difference on students' performance in online class at the beginning and at the end of the quarter. The goal is to reject this hypothesis and show that there is a significant difference between the same group of students as they have learned the material in this online environment. General statistical analysis was also conducted to see if the difference is positive (improvement) or negative (no improvement).

2) There is no significant difference on the CATS test results between students enrolled in Statics class with blended teaching method and asynchronous online teaching method. General statistical analysis was also conducted for comparison.

Many studies in these areas use a *t-test* to compare if a significant different observation exists between two different groups with different interventions. One constraint of this testing method is the data have to be normally distributed or the sample size needs to be sufficiently large. Otherwise, nonparametric method, such as *Mann-Whitney U-test* method, should be adopted. *Mann-Whitney* method is an equivalent non-parametric method of the *t-test*. It is often selected when the samples do not satisfy conditions of normality. Unlike the *t-test* that looks at the mean values, this method compares differences in median values between two independent samples. The calculation of the *p*-value is conducted using the *u_test* function in Octave computational software[12]. This value will be compared with a significance level value of 0.05. In addition, effect size parameter is calculated to measure the level of the magnitude of this difference.

Before testing the hypotheses, the data were checked for its normality using the *Lilliefors*[13] approach. A criteria value, $L_{criteria}$, is calculated based on the assumption that the distribution of the data are normally distributed. For this study, this value was calculated using the built-in *kolmogorov_smirnov* statistical function in Octave computational software[12]. This value is then compared to $L_{critical}$ value obtained based on the number of data and a significance level value of 0.05. If the criteria value is larger than this critical value, then it is concluded that the data are not normally distributed.

Results and Discussions

General statistical information based on students CATS test results for the 3 quarters observed in this study can be found in Table 2. The test result values are converted to 0-100 scale from its original 0-27 scale for ease of observation. Pre- and post- test results were collected for online classes (Quarter 2 and 3). However, only the post-test results were collected for the blended class

(Quarter 1). Steif and Hansen[14] reported that it is actually insignificant to collect pre-test data since the average score is close to random guessing average value (20). The pre-test averages for the second and third quarters (28.77 and 27.41, respectively) are slightly above this random guessing average. The reason may be because these pre-tests were administered around the end of the second week of the quarters and students already had more exposure to some concepts covered in the test, such as Parallelogram law, particle equilibrium, and some introduction to moment.

There are about 20 points improvement on the mean and median values when the pre- and post-test data are compared for the online groups. Another observation in Quarter 3 online group is the drop of sample size from 20 to 14. The major reason for this drop is strongly related to violation of academic honesty in the class. Lastly, the mean and median values of the post-test data for blended and online learning are about the same (mean: 47.01 blended vs 46.22 combined online data & median: 48.15 blended vs 44.44 combined online data). Some readers may question why the mean value is only about half of the maximum score. A comparison with the mean value from data collected by the CATS developers shows that the calculated mean value from these data sets is similar to the ones calculated in this study. It should be noted that these data were collected from students attending various four-year institutions. Hence, the range of mean values observed in this study is normal for this CATS results.

Table 2 General Statistical Data

	Data collected in this study							Data collected by CATS developers*
	Blended	Online						
	Qtr 1 Post Test	Qtr 2 Pre-test	Qtr 2 Post-test	Qtr 3 Pre-test	Qtr 3 Post-test	Combined Pre-test**	Combined Post Test**	Post Test
Number of Data	13	13	11	20	14	33	25	680
Mean	47.01	28.77	48.15	27.41	44.71	27.95	46.22	45.62
Standard Deviation	18.04	16.78	18.07	13.77	21.76	14.79	19.89	17.09
Median	48.15	22.22	44.44	22.22	40.74	22.22	44.44	
Max	81.48	59.26	74.07	66.67	92.59	66.67	92.59	
Min	14.81	11.11	22.22	11.11	11.11	11.11	11.11	

* These data are collected by the developers of CATS as part of its development from multiple higher educations in the United States[15]. Data from the developers' institution were removed to eliminate possible bias that the courses were taught in correlation to the questions in the CATS. It is also assumed that most of the teaching method when the data is collected is the traditional lecture style teaching method.
** The data are a combination of Qtr 2 and Qtr 3 data.

The next questions are whether the improvement between pre- and post- test data in online groups are statistically significant or not and whether the small difference between post test data of blended and online groups is statistically significant or not. These questions are related to the two hypotheses that are tested in this study. Before testing the hypotheses, the CATS test result data are investigated for its normality using the *Liliefors* approach that is based on the *Kolmogorov-Smirnov* method. The calculated $L_{criteria}$ values are presented in Table 3 together with the critical values that are obtained based on the number of data and the significance level value of 0.05. The criteria values for all of the data sets are above their corresponding critical values. Hence, it is concluded that the data sets are not normally distributed. When this result is combined with the less amount of data collected, a non-parametric *Mann-Whitney* approach is selected to test the two previously stated hypotheses.

Table 3 Normality Check of the CATS Test Result Data

	Blended	Online					
	Qtr 1	Qtr 2		Qtr 3		Combined	
	Post test	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
Number of Data	13	13	11	20	14	33	25
$L_{critical}$	0.2337	0.2337	0.2506	0.1920	0.2557	0.1518	0.1726
$L_{criteria}$	3.6054	3.6007	3.3166	4.4661	3.7366	5.7368	4.9933

The first hypothesis to be tested is that there is no significant difference on students' performance in online class at the beginning and at the end of the quarter. The goal is to reject this null hypothesis and shows that there is a significant difference between the same group of students in online class. The first three columns of Table 4 present the calculated *p-value* when the pre- and post- test results are compared for the second, third, and a combined second and third quarters. All of the calculated *p-values* are smaller than 0.05 (significance level value). Hence, the null hypothesis is rejected, meaning that there is a significant difference on students' performance after exposures to online learning, and it is a desirable difference based on the increase of the mean and median values between the pre-test and post-test results. The calculated size effect parameters (*r-value* in medium range) also confirms this observation. The result of this hypothesis testing shows that learning was occurred even though the online teaching was relatively new for many students and the instructor during the pandemic. Hence, the post-test results of the online teaching and blended teaching is compared together to investigate their difference.

Table 4 *p and r value* Calculated in the Hypotheses Testing

	Online Qtr 2 Pre vs post test	Online Qtr 3 Pre vs post test	Online Combined Pre vs post test	Posttest Blended vs Online Combined
p-value*	0.0175	0.0173	0.0005	0.6667
r-value**	0.4849	0.4081	0.4567	0.0699

*Indicate significant difference if p-value <0.05.
**Size effect parameter where $r<0.3$, $0.3<r<0.5$, and $r>0.5$ indicate the magnitude of difference is small, medium and large, respectively.[16]

The second hypothesis to be tested is that there is no significant difference on the post- test CATS test results between students enrolled in blended and online classes. The goal is to accept this null hypothesis. The fourth column of Table 4 presents the calculated *p-value* for the blended and online groups. A combined online data is presented in this paper, and the observations on a separate online group (Qtr 2 or Qtr 3) are consistent with the observation presented here. The calculated *p-value* is above 0.05. Hence, the null hypothesis is accepted meaning that there is no significant difference on the post test results between the blended and online data sets. This result is supported by a similar mean and median values between two data sets as presented in the previous paragraphs. Moreover, the size effect parameter is small indicating the magnitude of the difference between these two data sets is small.

This study has contributed to an evidence that asynchronous online learning can be as effective as blended learning in teaching Statics. It should be noted that this evidence is limited to the scope considered in this study. The authors of this paper also realize that this evidence does not generalize that online learning is an equivalently suitable teaching method for this course for all student groups considering that different students have different learning preferences. The first author found that some students were actually struggled to keep up with the asynchronous learning schedule especially in the beginning of COVID-19 pandemic. Hence, future more in-depth studies can be conducted to generalize this finding for wider student groups.

Two possible factors that explain the similar effectiveness observed between two teaching methods considered in this study are the sufficient amount of students' engagements and instructor presence. These two factors are important regardless the teaching method. In the blended teaching method, students' engagement components can be found in the quizzes following the pre-recorded videos, in class face-to-face problem-solving sessions, and assignments. Students were encouraged to solve these individual assignments in groups although not all students chose to do this. On the other hand, students' engagement components in the asynchronous online teaching are almost the same except that the in-person interactions in the blended teaching were replaced by more problem-solving videos and additional weekly online live problem-solving sessions. The asynchronous online has more instructor offline presence since it has more pre-recorded videos (20% more) than the blended teaching method. However, it has less live instructor presences (80% less) than the blended teaching method. Despite of this discrepancy, it should be noted that student-instructor interaction frequency (offline or online) in the online learning was still occurring on a daily basis through a combination of pre-recorded videos, weekly online live problem-solving sessions, and optional online office hours.

Many studies have shown that students and instructors appreciate the level of engagement they had during the problem-solving sessions in the blended teaching[4,3,5]. The same thing should be applied to the online learning. Online learning also needs to be engaging in its asynchronous format. There are many ways to design these engagement components in online learning, such as good quality videos, simulation, online demonstration, periodic assessments, including perhaps a scheduled office hour or weekly meeting similar to the one considered in this study. Many students in the instructor's online classes have expressed their appreciation for this brief weekly non-mandatory synchronous meeting (even if they just watched the recording) since it increases the level of engagement among students and instructor (e.g., they were able to meet and exchange contact to study online together, they were able to ask questions they had when watching the pre-recorded videos, and they were able to watch the questions discussed between their classmates and instructor). Therefore, future studies also can investigate students' level of engagement with these asynchronous learning resources (e.g. lecture videos, simulation features in textbook and videos, optional synchronous meeting) and determine what aspects and behavior in these engagements are detrimental or beneficial to students' success.

Conclusion

This study has presented an evidence that the asynchronous online learning can be as effective as blended learning method for Statics class within the scope considered in this study. This study rejects the first hypothesis that there is no significant difference on students' performance in online class at the beginning and at the end of the quarter and accepts the second hypothesis that there is no significant difference on the CATS results between students enrolled in Statics class with blended teaching method and asynchronous online teaching method. The asynchronous online learning considered in this study was designed based on the videos lectures that have been recorded for the blended learning. Additional problem-solving videos and a non-mandatory synchronous meeting (one hour per week) were added to replace the problem-solving sessions in blended learning and maintain level of engagement among students and instructor.

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Katie Gulliford

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