Comparing Blended and Traditional Instruction for a Statics Course

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Abstract

At Western Michigan University, Statics is a required course for students across several majors in the College of Engineering and Applied Science. Improving the teaching and learning effectiveness of Statics may have a major impact on student success and retention by virtue of the large number of students affected. Traditionally Statics has been taught through three 50-minutes or two 75-minutes face-to-face lectures per week. Since spring 2014, a redesigned Statics using blended course format has been offered parallel to the traditional format. The redesigned course format includes two 50-minutes lectures and one 3-hours recitation per week.

This study is purposed to perform a thorough comparison between the sections using the two instruction methods. The sample data includes students from Mechanical and Aerospace Engineering Department, and Civil and Construction Engineering Department enrolled into Statics course from Spring 2014 to Fall 2018. The demographic information of both student sections was compared first. The student cumulative GPA when they were enrolled in Static was examined to see if there were any differences between the two sections. The student performance, including their course grade and final exam grade, of the two sections was statistically analyzed. The students in both sections were divided into different groups based on their cumulative GPA then the same GPA groups were compared between the two sections. The academic performance of the students in the subsequent course, Mechanics of Materials, which is closely related to Statics was tracked and compared. The student and instructor perception about the redesigned course format was presented. The results showed that the students in the redesigned section outperformed the traditional section, and both instructors and students have perceived more active learning in the redesigned section. The university where this study was carried out is a Moderately Selective institution as classified by the Consortium for Student Retention Data Exchange. The lessons learned could be applicable to other institutions with similar student demographics.

Introduction

Statics is a sophomore-level course covering topics including equilibrium of force systems; analysis of trusses, frames and machines; centroid and moment of inertia of areas, etc. It serves as a prerequisite for several subsequent courses including dynamics, and mechanics of materials. Statics poses special challenge to engineering students because it is often the first engineering course they take. Moreover, students who have trouble with Statics often perform poorly in subsequent courses.

The pressing need to reform the teaching and learning Statics has been established in the past decades. To enhance teaching and student learning in Statics, researchers at various institutions have explored various methods for teaching Statics, such as developing concept map and

quantifying students' conceptual understanding [1, 2, 3], developing on-line homework or learning modules [4, 5], peer-led-team-learning [6, 7], project-based learning [8], emporium-based course delivery [9], etc. Among them, the flipped-classroom method [10, 11, 12] has become popular in the recent years. In a flipped classroom, the class time is devoted to guided instruction where students work through problems with the instructor present to provide assistance and answer questions. Lectures are delivered through on-line videos which students are required to watch and learn outside the class time. Other than a complete flipped classroom teaching, blended or hybrid learning gained popularity in teaching Statics and other engineering courses [13, 14, 15, 16]. Blended learning provides more engaging experiences by replacing some aspects of face-to-face teaching with hands-on activities and/or online learning, while still maintaining the traditional instruction elements.

Comparisons of student performance in flipped and traditional instruction in engineering courses have shown mixed results as reported in literature. Some studies reported that flipped instruction scored higher [17, 18, 19], while others reported there were no significant differences between the two instruction methods [10, 11, 20]. Interestingly, in a 1,089-member faculty survey conducted in 2015 [21], only 55% of the faculties saw evidence of improved learning.

In the College of Engineering and Applied Science at Western Michigan University, Statics is required for students across several majors. It is a 3-credit-hour course that has been taught in traditional face-to-face lecturing before 2013. Statics has been considered a difficult course in the college as measured by passing rate (the percentage of students getting a C or better). The passing rates in Statics classes from Fall 2010 to Fall 2013 were mostly below 60%. The low passing rate of Statics negatively impacted the 2nd-to-3rd-year retention rate of the college. Therefore, an effort to redesign Statics took place in 2013 with a pilot redesigned course implemented in spring semester of 2014. The team that engineered the redesign included two faculty members who teach Statics regularly and an Associate dean of Undergraduate Programs and Assessment. Beginning Spring 2014, students are given the options of enrolling in two redesigned Statics classes or one traditional class.

The redesigned course took a blended format, consisting of two 50-minutes traditional lectures and one 170-minutes problem-solving recitation session per week. Typically, during the lecture sessions, the instructor explains the theory associated with the topics covered in the week and solves a few examples. In the recitation sessions, students solve a set of pre-assigned problems which are due at the end of the sessions. Students work the assigned problems on paper and submit their results online for immediate feedback. During the recitation, peer discussion is allowed and encouraged, and the instructor and student teaching assistants (TAs) are present to assist the students if they need. In the recitation sessions, besides solving problems, students often take quizzes and mid-term exams; occasionally the instructor might demonstrate on solving more difficult problems. The course redesign was reported in detail in the authors' previous paper [22].

This paper reports on the results of a five-year study in Statics teaching and learning. The purpose of this paper is to compare the student performance in the redesigned section and the traditional section, and to evaluate how significantly the redesigned Statics has impacted student learning. The research questions were as follows:

1) Would the student performance differ between the two sections?
2) Would instructor and student perceptions differ between the two sections?
3) Would student performance in the subsequent course differ between the two sections?

Student demographic and cumulative GPA

To compare the student performance in Statics between traditional and redesigned sections, data was collected and analyzed for Statics students during the period from 2014 to 2018. In these five years, Statics was taught mainly by two instructors, who collaboratively led the effort to redesign the course. The two instructors have taught both traditional and redesigned classes. There were several traditional classes of Statics taught by other instructors. To maintain the consistency of the comparison, the students that were not taught by the two major instructors were excluded in this study. In addition, only the students from Mechanical and Aerospace Engineering Department, and Civil and Construction Engineering Department were included in the study. These resulted a total of 1208 students, among them 310 are from traditional section and 898 are from redesigned section.

The summary of student demographics is shown in Table 1 and Table 2. The data showed that the demographic information of the two sections was similar.

Table 1 Enrollment by gender and section

Section	Male (%)	Female (%)	Total
Traditional	279 (90%)	31 (10%)	310
Redesigned	806 (89.8%)	92 (10.2%)	898

Table 2 Enrollment by race/ethnicity and section

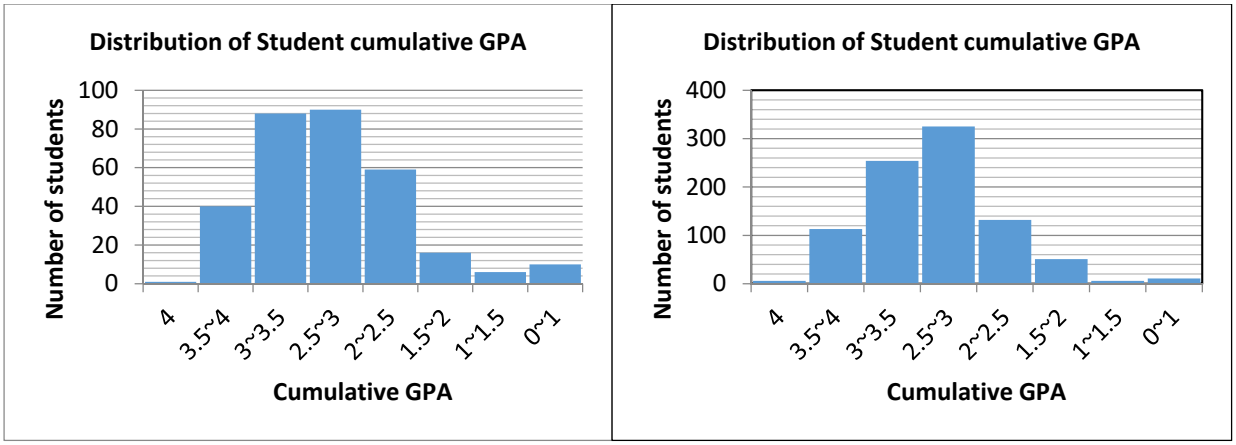
Race/ethnicity	Traditional (%)	Redesigned (%)
African American	12 (3.9%)	37 (4.1%)
Asian	9 (2.9%)	26 (2.9%)
Hispanic	9 (2.9%)	40 (4.5%)
International	32 (10.3%)	112 (12.5%)
Two or more	5 (1.6%)	17 (1.9%)
White	241 (77.7%)	651 (72.5%)
Other/Unknown	2 (0.6%)	15 (1.7%)

To see if there are any differences in academic background of the students entering into the two sections, the cumulative GPA of the students when they enrolled into the course is compared. Table 3 shows the descriptive statistics of the two sections. The redesigned section had a slightly higher average cumulative GPA. However, a statistical t-Test of the cumulative GPA of the two student sections assuming unequal variances was performed, and the results showed that the difference is insignificant at the 95% confidence level ($p = 0.068$, a p value greater than the specified significance level of 0.05 indicating statistically insignificant).

Table 3 Comparison of cumulative GPA

Section	Mean	Standard deviation
Traditional	2.77	0.74
Redesigned	2.86	0.60

Figure 1 shows the distribution of student cumulative GPA in the two sections, respectively. The GPA distributions of the two sections were similar.



(a) Traditional section **(b) Redesigned section**

Figure 1: Distribution of student cumulative GPA in the two sections

Student performance in Statics

Table 4 shows the comparison of the passing rate of the traditional section and the redesigned section of Statics. The redesigned section has a moderately higher passing rate compared with traditional section.

Table 4 Comparison of Statics passing rate

Section	Total no. of students	No. of students get C or better	Passing rate
Traditional	309	182	58.9%
Redesigned	898	608	67.7%

The final course grades were converted to numerical scale (A = 4.0, BA = 3.5, B = 3.0, CB = 2.5, C = 2, DC = 1.5, D = 1, E = 0) and compared between the two sections. The result is shown in Table 5.

Table 5 Comparison of Statics final grade

Section	Mean	Standard deviation
Traditional	1.93	1.23
Redesigned	2.17	1.26

The redesigned section has higher mean course grade compared to the traditional section. A statistical t-Test of the final grade in numerical scale of the two student sections assuming unequal variances was performed. The results showed that the difference is significant at the 95% confidence level ($p = 0.034$).

The students in both sections were divided into six groups based on their cumulative GPA (3.5~4.0, 3.0~3.5, 2.5~3.0, 2.0~2.5, 1.5~2.0, 0~1.5). The Statics final grades of the same GPA groups were compared between the two sections and the result was shown in Table 6. The redesigned section has higher average course grades in all cumulative GPA groups except the 1.5~2.0 group. One argument while comparing different instructional methods is that excellent students are relatively more likely to master course material regardless of the instructional approaches. From the data shown, in the cumulative GPA 3.5~4.0 group, redesigned section still has significantly higher average course GPA than the traditional section. This shows that instructional approach matters even for excellent students.

Table 6 Comparison of Statics final grade in different cumulative GPA groups

Cumulative GPA groups	Section	Number of students	Mean	Standard deviation
3.5~4.0	Traditional	43	3.26	0.84
	Redesigned	119	3.64	0.63
3.0~3.5	Traditional	87	2.53	0.99
	Redesigned	254	2.67	0.98
2.5~3.0	Traditional	90	1.70	0.99
	Redesigned	325	1.91	1.02
2.0~2.5	Traditional	59	1.22	0.87
	Redesigned	132	1.31	1.06
1.5~2.0	Traditional	16	0.72	0.86
	Redesigned	51	0.70	0.89
0~1.5	Traditional	16	0.19	0.40
	Redesigned	17	0.35	0.61

In order to compare the student performance in the two sections, all students took the same final exam at the same time in four semesters (Spring and Fall 2014, Fall 2015 and Fall 2016). The analysis of the result showed that the final exam score in both sections are very close. The statistical t-test of final exam scores of the two student sections indicated the difference was insignificant. The detail was reported in the author's previous paper [23].

Based on the aforementioned data analysis, it is concluded that the redesigned section outperformed the traditional section in mean final course grade and passing rate. However, it is worth mentioning that it appeared little differences between the two sections when they took the same final exam in the four semesters.

Student performance in a subsequent course

All of the students from Mechanical and Aerospace Engineering Department, and Civil and Construction Engineering Department are required to take ME2570 – Mechanics of Materials. Since Statics is a prerequisite course of Mechanics of Materials and the two courses are closely related, we use the student performance in Mechanics of Materials to track the differences between the traditional and redesigned Statics sections when they move on to the subsequent courses.

Not all students in the sample we use in this study took Mechanics of materials. The reasons could be: all students took Statics in Fall 2018, and some students took Statics in spring 2018 and Fall 2017 have not completed Mechanics of Materials yet; some students who took Statics have withdrawn from engineering programs so they did not take Mechanics of materials. Out of 310 students in traditional section and 898 students in redesigned section (the sample students we use in this study), there were 193 students in traditional Statics section and 596 students in redesigned Statics section took Mechanics of Materials.

Table 7 showed the comparison of passing rate in Mechanics of Materials between the students who took traditional and redesigned Statics. The result showed that the students who took redesigned Statics has a higher passing rate in Mechanics of Materials compared with the students who took traditional Statics.

Table 7 Comparison of Mechanics of Materials passing rate

Section	Total no. of students	No. of students get C or better	Passing rate
Students who took traditional Statics	193	126	65.3%
Students who took redesigned Statics	596	418	70.1%

Again the final course grades of Mechanics of Materials were converted to numerical scale (A = 4.0, BA = 3.5, B = 3.0, CB = 2.5, C = 2, DC = 1.5, D = 1, E = 0) and compared between the two sections. The result is shown in Table 8. The average course grade of the students who took redesigned Statics was slightly higher than those who took traditional Statics. However, a statistical t-Test of the final grade in numerical scale of the two student sections assuming unequal variances was performed and the results showed that the difference is insignificant at the 95% confidence level ($p = 0.529$).

Table 8 Comparison of Mechanics of Materials final grade

Section	Mean	Standard deviation
Students who took traditional Statics	2.05	1.13
Students who took redesigned Statics	2.11	1.15

Student and instructor perception

Anonymous student surveys were conducted among the redesigned classes near the end of spring and fall semesters of 2014, and spring semester of 2015. The survey contained eighteen statements related to students' perception of the redesigned course, and students answer each question with a scale of 1 (strongly disagree) to 5 (strongly agree). At the end of the survey there was a section for the students to leave comments. The survey results showed that most students liked the redesigned approach. Students expressed that they were able to work more problems and learn the materials better in the redesigned format. Overall the feedback for the redesigned course was quite positive. Table 9 summarizes the student response to statements 16 and 17 of the survey. The detailed survey results were reported in the authors' previous paper [22].

Table 9 Student survey responses in the three semesters (Total 211 students)

Statements	5 Strongly agree	4 Agree	3 Neutral	2 Disagree	1 Strongly disagree	Mean
16. I believe that I learned the material better using the new approach than the traditional approach	97	66	32	11	5	4.13
17. Overall, I like the new approach better than the traditional approach	95	65	29	14	8	4.07

On the instructors' perception side, it is the two main instructor's agreement that students in the redesigned classes are more engaged in learning than those in the traditional classes. A majority of the students are more actively involved in the hands-on learning process by solving the problems in the recitation sessions. Also, in the redesigned classes, the instructors know each student better because of the significantly increased level of instructor-student interaction in the recitation sessions.

Conclusion

To improve the student learning in Statics, the faculty in the College of Engineering and Applied Science at Western Michigan University initiated a course redesign and started to implement it from spring semester of 2014. The major change of the redesigned course format is reducing the traditional lecturing time and adding weekly recitation session, during which students solve problems with the guidance of the instructors and TAs if needed.

To determine how significant the course redesign impacted the student learning, data from Spring 2014 to Fall 2018 has been collected and statistical analyses have been conducted and reported in this paper. The results showed that the students in the redesigned section outperformed those in the traditional section in mean final course grade and passing rate, even though the final exam grades of two sections had no statistically significant difference In addition, the feedback of the students and the perception of the instructors are in favor of the

redesigned course format. By tracking the student course grade in a subsequent course, Mechanics of materials, it is concluded that the students took redesigned Statics had higher passing rate and mean course grade in Mechanics of Materials than those who took traditional Statics.

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