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The Effectiveness of Flipped Classroom on Students' Performance and Satisfaction in a Biostatistics Course

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Abstract

This paper investigates the effectiveness of the flipped classroom approach on the performance of a group of students in a biostatistics course at Palestine Polytechnic University (PPU). A questionnaire and the class performance are used as the study instruments to evaluate the effectiveness of this approach. The results are compared with another homogeneous group of students using conventional learning. Statistical analysis is carried out to check the significant difference between the two groups. The analysis reveals that the flipped classroom had better class performance and a higher level of satisfaction than conventional learning.

Keywords: *flipped classroom, university class, alternative-learning methods.*

Introduction

Many of the teaching strategies used in higher education systems are conventional, teacher-centered, and do not meet students' needs and learning styles. The rest of the world has incorporated technology in its daily activities because technology can bring satisfaction and help learners learn faster, more enjoyable (Tamimi,

2017). Thus, pedagogy should also work with new technological advancements and innovation. Teaching and learning should take advantage of technology and use learner/learning-centered teaching, where learners are involved in the process and are engaged with their peers and their teachers in discussions, analysis, and feedback. Such engagement can positively influence learners' performance and the overall learning experience. Recently, academic institutions have encouraged their teachers to use new learning techniques in their classrooms rather than the conventional techniques, especially those that incorporate technology. One of those promising techniques is learning based on the flipped classroom.

Flipped classroom (FC) learning is vital because it integrates the work at home and the activities inside the classroom. In practice, FC is much more than flipping the order of class and activities. It is a new teaching method that involves practicing problems as homework before the class, not after. It also requires that learners look at and analyze those problems actively using group-based work and problem-solving activities together during the class. The idea of FC is based on reversing learning tasks between the classroom and home. In this mode, the teacher prepares videos, readings, apps and assigns them to learners. Students, in return, are required to do all needed preparation to understand and gain knowledge about the topic addressed beforehand on their own, so they can participate in the class activities. When in class, the learners and the teacher engage in discussions, analysis, and problem-solving related to the work given outside of class beforehand. The class time is also used to provide feedback to students on their work and answer any questions. Bloom revised Taxonomy (Anderson & Krathwohl, 2001) aligns with FC in the sense that the material given to learners to be done outside the classroom engages the lower cognitive skills of the taxonomy, such as understanding and gaining knowledge. On the other hand, the higher cognitive skills such as applying, analyzing, evaluating, and creating are addressed inside the classroom through discussion, problem-solving, analyses, and feedback (Charles-Organ & Williams, 2015) (Figure 1).

This research aims at examining the performance of learners in the FC setting compared to the traditional setting, in which the teacher introduces material during class time. It also aims to study the FC's effect on their satisfaction with their learning experience.

Literature Review

The FC is known by various names, including the inverted classroom and, more simply, the flip. Different scholars used variations of this method. However, the most known first use is attributed to Bergmann and Sams (2008), who

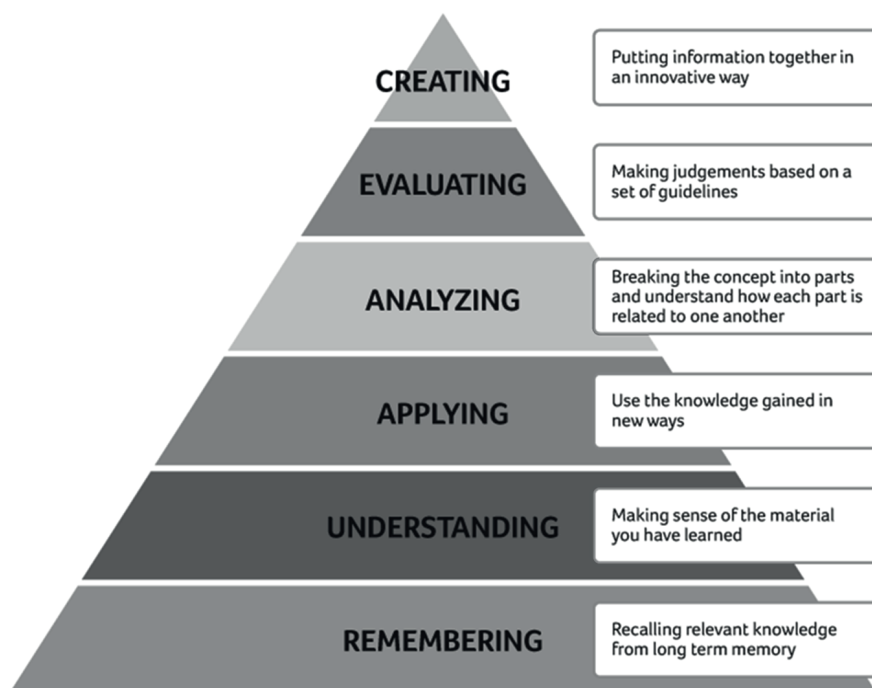


Figure 1. Bloom's Taxonomy (Revised)

used FC in a chemical course to help students (particularly absent students) understand the material by watching recorded lectures at home and doing their homework in class.

Various scholars have given different definitions of FC. Lage et al. (2000) explained flipped classrooms as “events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa” (p. 32). Bishop & Verleger (2013) and Zhou & Jiang (2014) defined FC as an educational technique that consists of two parts: interactive group learning activities inside the classroom and direct computer-based individual instruction outside the classroom.

Several studies have shown the impact of FC on students' academic performance and satisfaction. For example, Marlowe (2012) studied the impact of FC on students' achievement and their stress levels. The study was conducted on 19 students enrolled in the environmental systems and societies course in Dubai American Academy. Part of the course was taught by the conventional method, and the other part by the FC method. The findings showed that the stress level

was lowered in the FC setting, and there was an average increase of three points (out of 16 total) in students' grades compared to the previous semester. A study by Love et al. (2014) involving 55 students in 2 sections of a linear algebra course used the conventional lecturing in one section and the FC model in another. Students were compared across sections on three mid-semester and one final exam. All exam results showed that students in the FC had higher scores than the students in the conventional method. Also, a survey filled out by the students has shown a positive attitude regarding the course. Thai et al. (2017) conducted their study on 90 students enrolled in an Invertebrates course in Can Tho University, Vietnam. Students were randomly assigned to one of the four groups (FC, Blended Learning, Conventional Learning, and E-Learning). The study examined the four settings on learning performance, self-efficacy beliefs, intrinsic motivation, and perceived flexibility. Students in the FC showed positive effects on self-efficacy beliefs and intrinsic motivation but not on perceived flexibility. Moreover, learning performance was higher in FC than other learning settings.

Chun and Heo (2018) investigated the effectiveness of FC in terms of both self-efficacy and academic performance. In their research study, they found a significant association between the use of the FC and improvements in self-confidence. However worthy to note that no statistically significant relationship was found between the FC and improvements in self-efficacy, self-regulation, and motivation. Jdaitawi (2019) looked into the effects of FC in autonomous learning and social consecutiveness. This study is conducted at Imam Abdulrahman Bin Faisal University. The study involved 160 students enrolled in health, engineering, and sciences courses. The students were divided into a control group (CG) using a traditional setting and an experimental group (EG) using FC. The results revealed that the EG showed a significantly higher level of self-regulation and social connectedness over the CG. Alamri (2019) also investigated the effectiveness of FC on students' performance and satisfaction. His study was conducted at King Faisal University – Saudi Arabia. Two groups of students were taught a course in educational technology; one group underwent the conventional classroom, and the other group underwent the FC. This study indicated a statistically significant difference in students' performance in the FC group, and almost all students had a higher level of satisfaction, stating that they enjoyed learning in the FC environment. Unal and Unal (2017) investigated how the implementation of FC can affect students' performance and perceptions, and teachers' satisfaction. Their study involved 16 teachers and 623 students. They showed that utilizing FC positively influenced students' performance and perceptions, and teachers' satisfaction.

Purpose of the Study

The aims of this study are as follows:

1. To explore the advantage of a FC over conventional learning in terms of students' performance.
2. To study the effect of FC on student satisfaction.
3. To study the possibility of teaching a biostatistics course using a FC.

Research Hypothesis

There is a statistically significant difference between the students' performance who underwent the conventional approach and those that underwent the FC approach.

Research Methodology

General Background

This study was conducted using a quasi-experimental approach on two intact groups: CG and EG. The CG attended a biostatistics course at Palestine Polytechnic University in the first semester of the academic year 2017/2018, while the EG attended the same course in the second semester of the same academic year. Only one section of this particular course is offered every semester, which is why the study took place during two separate semesters.

In the CG, 18 students participated in the conventional learning (conventional lecture form through blackboard and a piece of chalk). In the EG, 20 students participated in the FC. Both groups were taught the same course (same syllabus and content). As for the course evaluation, the lecturer designed the same assignments, projects, exams, and quizzes and used the same rubric to assess the students. Both groups were given the course assignments and exams to measure their performance. In the EG, FC students were introduced to lecture materials (online materials and video lectures) before the class time, and then the class time was devoted to problem-solving and discussion. Video lectures were averaged 50 min in length and consisted of Dr. Samuh's lecture (fourth author of this paper) over a OneNote presentation. Students were encouraged to take notes and write questions to be discussed during class time. To ensure that the students have seen the lecture at home, the instructor was asking questions at the beginning of each class, and it has been noticed that most of the students raised their hands to participate. Moreover, it was noted that the average number of views per video lecture was about 30 views for the 20 students of FC. The students' performance

was measured according to their GPA of the assessment components. The grades were recorded out of 100. At the end of the semester, the students in the FC were voluntarily asked to fill in a questionnaire to measure their satisfaction with the course.

Statistical Analysis

Grades and data were analyzed by the statistical software RStudio (RStudio Team, 2020). The following statistical methods were used. To test for significant differences in central tendency (multivariate mean) between two independent homogeneous samples with normal distributions, the Hotelling T^2 test is used. The independent t-test was used to determine whether there is a statistically significant difference between the means in two independent homogeneous groups. Normality assumption is tested with the Shapiro-Wilk's test, and equality of the variances' assumption is tested with Levene's test.

Participants

Participants of the groups were 2nd-year health nutrition students. To ensure homogeneity between groups, students were majoring in health nutrition, none of the students had previous exposure to the given course, and all students finished their scientific stream high school (HS) certification with a minimum score of 70. Table 1 shows some statistics for the HS scores for both groups. It also shows some statistics for their GPA at the university.

Table 1. Some statistics for the students' GPA

Group (n)	Variables	Min	Max	Mean	SD	95% CI
CG (18)	HS Score	70	96.3	80.12	8.74	(76.08, 84.16)
	Undergraduate GPA	61.9	92.8	77.50	8.63	(73.51, 81.49)
EG (20)	HS Score	70	94.8	82.76	7.10	(79.65, 85.87)
	Undergraduate GPA	64.8	91.8	78.98	6.65	(76.07, 81.89)

Figure 2 shows the Boxplot of the mean values of the HS and Undergraduate GPA scores for the CG and EG. It can be seen that the means of HS and GPA scores are higher in the EG than in the CG. A two-sample Hotelling's test was performed to test if this difference is statistically significant. The results are as follows.

The two-sample Hotelling's statistic is 0.638 with 2 and 35 degrees of freedom. The p-value is 0.5344, which is greater than the nominal level of significance

0.05. Thus, in this case, we can conclude that the mean vector for the EG equals the mean vector for the CG. That is, the difference between the means of the HS and GPA scores for both groups is not significant. Thus, we can conclude that both groups are similar.

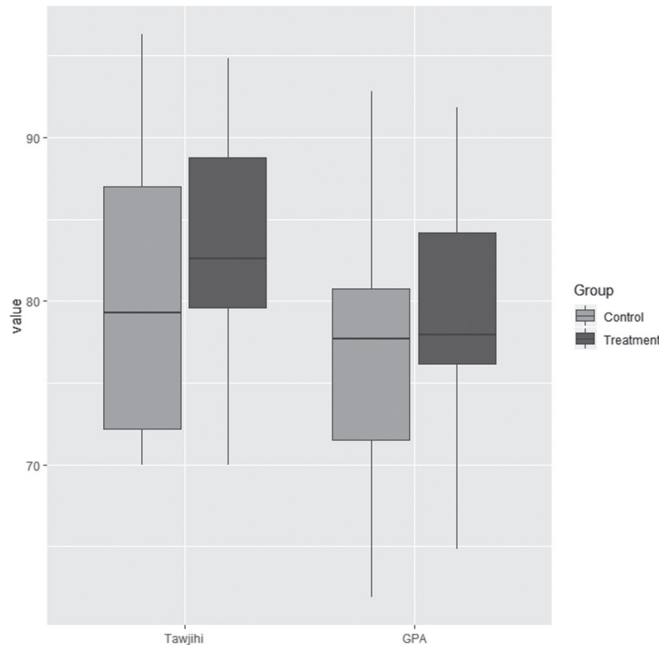


Figure 2. Boxplot of the mean value of HS and GPA for each group

These conclusions can be trusted if the assumptions of the Hotelling's are valid. Normality assumption is tested with the Shapiro-Wilk's test, and equality of variances is tested with Levene's test. The results of Shapiro-Wilk's test are shown in Table 2, and the results of Levene's test are shown in Table 3. All tests yield non-significant p-values, showing that the hypothesis that the samples come from a population that has a normal distribution and the hypothesis of homogeneity of variance cannot be rejected.

To sum up, both students groups are homogeneous. Thus, if any differences will be found in the biostatistics scores between the experimental and CG, it will be attributed to the teaching method. Table 2. Normality test

Group (n)	Variable	Statistic	p-value
CG (18)	HS Score	0.9045	0.0689
	GPA	0.9480	0.3939
EG (20)	HS Score	0.9435	0.2790
	GPA	0.9662	0.6743

Table 3. Equality of variances test

Variable	Statistic	Df ₁	Df ₂	p-value
HS Score	2.8286	1	36	0.1013
GPA	0.7638	1	36	0.3879

Results of Research

Students Performance

In this section, the FC approach's impact on the students' performance is highlighted. The independent t-test is performed to identify any statistically significant differences between the two groups' scores (of the biostatistics course).

Before carrying out the t-test, its assumptions need to be checked out. The independent assumption is valid because the two groups are not related. The normality assumption is valid according to the results of Shapiro-Wilk normality test. The results are reported in Table 4, and the test yields non-significant p-values. The equality of variance assumption is also valid according to the results of Levene's test. The results are reported in Table 5, and the test yields a non-significant p-value.

Table 4. Normality test for the Biostatistics scores

Group	Statistic	p-value
Control (18)	0.9408	0.2486
Experimental (20)	0.9067	0.0752

Table 5. Equality of variances test for the Biostatistics scores

Statistic	Df ₁	Df ₂	p-value
2.7549	1	36	0.1056

Now, our concern research question is:

Are there any statistically significant differences between the scores of the CG and EG? In other words, has the FC approach resulted in better performance than the conventional approach or vice versa?

An independent-samples t-test was performed on the biostatistics course to verify this hypothesis. The results are reported in Table 6. It is clear that there is a significant difference in the scores for the EG (Mean=81.80, SD=9.128) and CG (Mean=71.83, SD=13.285); $t_{(36)}=2.7186$, and $p\text{-value}=0.01$. These results suggest that FC has a positive effect on biostatistics scores. Specifically, our results suggest that their performance improves when students attend flipped teaching methods.

Table 6. Independent t-test for the Biostatistics scores

Group	Mean	SD	t-statistic	Df	p-value
CG (18)	71.83	13.285	2.7186	36	0.0100
EG (20)	81.80	9.128			

Figure 3 suggests that the mean scores for the students who attended the FC approach are higher than in the conventional approach.

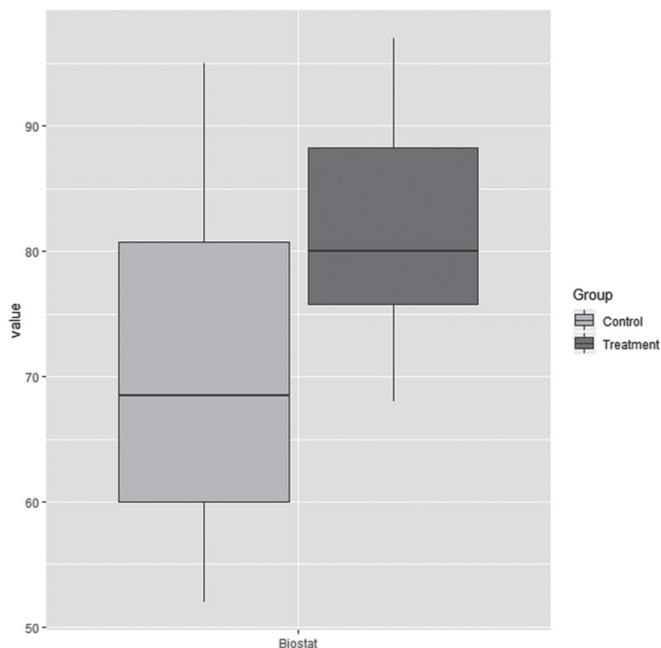


Figure 3. Boxplot of the mean scores of the biostatistics course

Students' Satisfaction

An ad-hoc questionnaire was designed to measure the students' satisfaction level (in terms of students' needs, wishes, and expectations) about the FC approach. The questionnaire consists of three sections; 1) demographics items, 2) satisfaction level (14 items), and 3) open-ended items. Section 2 is designed using a 5-point Likert scale (ranging from (1) strongly disagree to (5) strongly agree). The 20 students in the FC answered the questionnaire. Table 7 shows the statistical analysis of the students' satisfaction with the FC. It is worth noting that the conventional classroom students were not included in this questionnaire because they could not provide their satisfaction with the setting they were not part of. The study suffices with the statistical significance in performance by the FC over the conventional one.

As shown in Table 7, most of the students liked to learn through the lecture videos prepared by the teacher (item 4). Items 2, 8, 9, 14 got the 2nd highest rank. These items are in favor of using the FC approach. While the lowest rank was for Item 6, which says, "The time that I spent in watching the lecture videos was better to be spent in the class", which is also in favor of using the FC approach. According to this analysis, after reading the answers to open-ended items, students showed positive feedback and were more satisfied with the FC approach.

Overall, our findings confirm that the FC has improved the students' performance and showed a high level of students' satisfaction.

Discussion

The results suggest that flipped learning can be an effective approach in teaching Biostatistics and, probably, any other discipline. Flipped learning group outperformed the conventional group. They had the advantage of preparing at their own pace and enjoying the classroom activities and discussions because they could ask for clarification and get accurate answers. They appreciated that they had a voice and they could be heard. They were motivated because they saw outstanding performance and an easy grasp of the topics of the subject. Their higher cognitive skills were developed, and applying them was beneficial compared to memorization. They realized that flipped learning was a better way to learn the material, create a deeper understanding of the content, and therefore excel.

In finding solutions to the disadvantages addressed in the literature, we realized that in order for the students to be more engaged and prepare their work at home, they needed to find a value in their home preparation reflected in the classroom

Table 7. Students' satisfaction with the FC

Item #	Statement	Strongly agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly disagree (%)	Mean	sd	Overall percentage	Rank
1	I was more motivated in the FC in comparing with other courses taught by the traditional learning	18.2	59.1	18.2	4.5	0	3.91	0.75	78.2	5th
2	The use of Facebook group that was used in the FC helped me in learning	22.7	63.6	9.1	4.5	0	4.05	0.72	81	2nd
3	FC gave me the opportunity to collaborate with other colleagues in my class	18.2	63.6	4.5	13.6	0	3.86	0.89	77.2	6th
4	I liked to learn through the lecture videos prepared by the teacher	54.5	31.8	4.5	9.1	0	4.32	0.95	86.4	1st
5	The prepared lecture videos gave me the opportunity to learn better than what I would learn in the class	36.4	36.4	18.2	9.1	0	4	0.98	80	3rd
6	The time that I spent in watching the lecture videos was better to be spent in the class	4.5	9.1	18.2	54.5	13.6	2.36	1.00	47.2	9th
7	Learning using FC is more flexible and enjoyment than face-to-face in class learning	22.7	40.9	31.8	4.5	0	3.82	0.85	76.4	7th
8	FC will benefit me in my educational future	22.7	59.1	18.2		0	4.05	0.65	81	2nd
9	I recommend my colleagues to join FC	27.3	54.5	13.6	4.5	0	4.05	0.79	81	2nd
10	I will be more motivated in learning biostatistics course or any other scientific curriculum if it would be taught by FC approach	31.8	45.5	9.1	13.6	0	3.95	1.00	79	4th
11	FC approach had the role to improve my learning in this course	31.8	50	4.5	13.6	0	4	0.98	80	3rd
12	FC approach gave me the opportunity and time to practice more in solving more exercises	18.2	63.6	4.5	9.1	4.5	3.82	1.01	76.4	7th
13	FC approach is more attractive than the traditional classroom	18.2	59.1	4.5	18.2	0	3.77	0.97	75.4	8th
14	I prefer teaching methods that use technology irrespective of its type (FC, blended classroom, e-learning, etc.) over the traditional teaching methods	27.3	59.1	4.5	9.1	0	4.05	0.84	81	2nd

work. When some of the students at the beginning of the FC did not prepare the assigned material at home, they changed their minds and started preparing because they realized that they could not understand or cope with the class and the activities without preparing at home. We believe that was a good solution for this challenge. As for the other disadvantages of creating and integrating classroom activities, we believe that teachers need to be trained to use flipped learning. It can be a major challenge if the teacher is not prepared to switch to flipped learning, and the results can be devastating.

Conclusion

Based on the findings of this study, it can be concluded that the FC approach has a positive effect on the performance and satisfaction of the students. During the lectures, it was noted that the students who attended FC were more motivated than those who attended conventional classrooms. Moreover, student participation was much higher in FC approach than in the conventional approach. To this end, it is highly recommended to use the FC approach in a Biostatistics course and any other courses. Based on this research, a similar study can be conducted for other courses and students with different characteristics.

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