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Comparative Analysis of Student Performance in Flipped and Traditional Classroom Models

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Abstract

Rapid change in technology has transformed the way of interaction between the teacher and student especially in engineering education where large classes are now common. Students have changed how they want to learn and how quickly they want feedback in their learning. Flipped classroom model has become very important as it promotes active involvement and participation by students and allows the teacher to efficiently engage with students in their learning process. This research study investigates the impact of flipped and traditional classroom models on student performance among third year electrical engineering students. The sample sizes that were considered are 71 and 44 students for year 2019 and 2022 respectively. In the flipped classroom model students were instructed to watch pre-recorded videos before the lecture and during lecture time interactive learning was used to discuss the lecture content. The students performance on four tests were compared between the two groups using t-test analysis. The results show that students who experienced flipped classroom model performed better than the students who attended the traditional class-room model. This finding supports that teaching methods that include interactive learning strategies such as a flipped classroom model can be effective ways of disseminating key engineering concepts to university engineering students.

Keywords: t-test, flipped classroom, teaching, student performance

1 Introduction

Modern teaching methods are widely used in higher education. This has been exacerbated by the fast adoption of technology in the education system during the coronavirus disease 2019 (COVID19) pandemic period. Different technologies such as video games, social media (whatsapp, telegram etc), ipads and more have changed the way students interact with their teachers and how quickly they want feedback in their learning. While traditional methods of teaching are still very important, it has become apparent that the use of innovative technologies, pedagogical and information technologies in the educational system cannot be ignored [Tucker, 2012; Bishop & Verleger, 2013; Roth et al, 2014; Critz & Knight, 2013]. Traditional methods of teaching have been designed to teach students ready-made knowledge and students are regarded as passive learners. However, the fast-paced technological advancement in the world requires the student to be taught how to search for new knowledge, learn and analyze independently and draw independent conclusions on subject matters [Roth et al, 2014; McLaughlin et al, 2013; Wong et al, 2014]. In such a scenario, the teacher needs to create conditions for the development, formation, acquisition and upbringing of a student to acquire knowledge and mature skills in their learning process. Flipped classroom model is very important in such a set up. The following subsection will look at flipped classroom model in detail and the contributions of this research study.

1.1 Flipped Classroom Model

Flipped classroom model is a teaching method that is defined in many ways. According to DeLozier & Rhodes, 2017, the concept of flipped classroom means the use of technology tools such as videos, presentation slides, audios etc to present concepts or information about the lecture to students outside of the classroom and devoting class time to different learning activities such as quizzes, practices, exercises. The students are required or expected to review the prepared material before attending the lecture. During lecture time, the teacher will help the students to solve the different learning activities. In Bishop & Verleger, 2013 flipped classroom is defined as a student-centered learning method consisting of interactive learning activities during lecture time and computer-based individual teaching outside of the classroom. Bergmann & Sams, 2012 explained flipped classroom as, '*what is done at school done at home, homework done at home completed in class'*. The resources and materials required to do work at home is shared by the teacher before class. During lecture time the focus will be on problem solving, discussion, brainstorming and the teacher will be responsible to guide the students in this learning process. Anorld-Garza, 2014 defined flipped classroom as, *'a teaching method that delivers lecture content to students at home through electronic means and uses class time for practical application activities that may be useful for information literacy instruction'* The previous definitions of flipped classroom model show the importance of technology in student learning process. It also shows the role of the teacher as that of a mediator or motivator of students. The students learn basic concepts of the subject using technology tools and comprehend these concepts in depth during lecture time. The flipped classroom model therefore gives students a real opportunity to construct knowledge and negotiate meaning collaboratively throughout different learning activities designed by the teacher who takes the role of facilitator/mentor in the classroom.

Literature review shows that flipped classroom model has been studied in different contexts. In a study done by Unal & Aslihan, 2017, the results showed that in most cases students who experienced flipped classroom model have higher student learning gains, more positive student perception, and higher teacher satisfaction compared to students who experienced traditional classroom model. The case study involved sixteen teachers who implemented flipped classroom model in their classrooms. Student and teacher surveys were conducted and student

perception on the teaching methods and teacher satisfaction scores were collected. Another case study was done by Blair et al, 2017 were the researchers investigated the impact of flipped classroom model on student experience. The case study was based on an undergraduate Material Technology course at the University of the West Indies. The course was taught using traditional and flipped classroom models in two consecutive years. The results from the case study showed that students who experienced flipped classroom model have a slight improvement on how they perceive the course and the lecturer's reflection shows that flipped classroom model allowed more time for them to work with students at an individual level. There was no significant change in the average exam performance scores of the students in both teaching methods. The recommendation from this case study was that teachers who intend to use flipped classroom model should pay much attention to student performance rather than student perception. Wei et al, 2020 explored different strategies of managing flipped classroom model for mathematical learning performance in middle school students. In the flipped classroom model students were allowed to take notes while watching videos at home and the teacher utilizes the notes for in-class discussion. A total of 88 students were involved in the study. The results showed that the proposed flipped classroom model significantly improved the student learning performance. In Covill & Cook, 2019 a comparison of student performance between traditional and flipped classroom models were conducted. Three cohort years of a third year classes from physical therapy education program was considered in the study. The class was taught by traditional classroom model in first year and with flipped classroom model the next two years. Correlation analysis of the examination scores between the cohorts were performed. The results showed that the learning outcomes of traditional and flipped classroom model were similar although student satisfaction was higher in flipped classroom model. Wong et al, 2014 conducted a case study on three different courses – basic sciences, pharmacology and therapeutics using flipped classroom model. The research study showed that examination scores were significantly higher in pharmacology and therapeutics but not in basic sciences. From the literature covered in this paper it clearly shows that there is no consistency on the success of flipped classroom model. Some researchers consider flipped class-room model as an advanced teaching method that should define the future standard of teaching and student learning. On the other hand, other researchers suggest that flipped classroom model is an ineffective teaching strategy. This situation encouraged the researcher to conduct this research study in an attempt to establish the impact of using flipped classroom method that uses interactive learning strategies among third year electrical engineering students. The contributions of this research study are that the results will provide recommendations in developing and application of flipped classroom model in engineering education and guide teachers involved in teaching engineering courses how to develop curricula that uses modern technologies through flipped classroom model of teaching. In addition, there is rarity of such studies according to the best knowledge of this researcher, which means the research study will be of paramount importance and will contribute to engineering education literature related to use of interactive learning strategies in flipped classroom model. The study seeks to answer the following research question: *Is there a significant difference of student performance scores attributed to teaching method variable?*

2 Materials and Methods

Data was collected from third year electrical engineering students that were doing a Power Systems engineering module. The module is done in the first semester of the year – from February – June). The years that were considered are 2019 (pre-COVID19 period) and 2022 (after the COVID19 period). In the pre-COVID19 period all the lectures were conducted using traditional lecture format and after the COVID19 period all lectures were conducted using the

flipped classroom model. The Power Systems module was divided into two outcomes. In each of the outcome the students were given to write two tests and the tests were similar for the considered years. In each test there were 4 question that covers the pedagogical objectives of the module in terms of 'memorization', 'comprehension' and 'application'. The tests are described as oa1/TEST A1, oa2/TEST A2 for two tests written in the first outcome and ob1/TEST B1 and ob2/TEST B2 for two tests written in the second outcome.

Sampling design and statistical tools: Test score data was collected from third year electrical engineering students doing Power Systems engineering module. A convenience sampling method was adopted for collection of student performance score data. The performance scores of each student who wrote all two tests in each outcome were considered in the data analysis. Students who could not write all the four tests were excluded from the sample. The total number of students that were considered in each of the tests is shown in Table 1.

Data analysis was done using a statistical software tool known as STATA software. Descriptive statistics – mean and standard deviation of the student performance scores were calculated and t-test statistics was used to test the null hypothesis. The null hypothesis for the research question in this research study is, '*There is no significance difference in students performance scores attributed to teaching methods*'. The student teaching method is used as the grouping variable in the analysis.

Table 1: Total number of students considered in each year

Year	***Total number of student numbers***	
	oa1 & oa2	*ob1 & ob2*
1	71	71
2	44	44

Statistical Analysis: The collected student performance scores of years 2019 and 2022 results were analysed by using descriptive statistics and t-test analysis. The t-test analysis was performed at a significance level of 0.05.

The main aspects of the learning environments for the different teaching methods are shown in Table 2.

Table 2: Characteristics of learning environments for different teaching methods

Teaching method	**In-class activities**	**Out-of-class activities**
Traditional classroom	• Lecture	Tasks – assignments, simulations.
Flipped classroom	• Individual assessment • Group discussion • Presentation • Tutorial test	Videos Access to other resources Assignment, simulations

The students who experienced the traditional classroom model were taken as the control group while students who experienced the flipped classroom model were taken as the experimental group. In the traditional classroom model, all lectures were delivered in large classroom setting and students were allowed to have access to internet use. During lecture time the lecturer explained different concepts to the students and gave them notes as presentation slides. Students were allowed to make their own notes during the lecture presentations and additional

lecture notes were uploaded on the online platform provided by the university. Recommended textbooks were also given to students for them to do further reading as out-of-class activity. After each topic that covers a range of different engineering concepts, the students were given assignments and simulation practice questions for them to do as out-of-class activities. The students were encouraged to do group discussions when answering the out-of-class questions, however, they were not allowed to plagiarize. The students would then submit the answered questions for marking after some given period of time. This form of out-of-class activities focus on both sub-skills such as understanding as well as application of higher order thinking skills such as analysing, evaluating, and creating as defined by Anderson, 2005. The course was divided into two modules and in each module the students were allowed to write two tests. In implementation of the flipped classroom model the lowest levels of cognitive domain of remembering and understanding were practiced outside the classroom while higher forms of cognitive work such as applying, analysing, evaluating, and creating were practiced in classroom. The lowest levels of cognitive domain were presented to students before class through recorded lectures and videos. The students were assigned to watch the pre-recorded videos, do the simulations and reading from recommended textbooks prior to class. The students were not held accountable for this assignment. Readings, simulations, and other materials provided the foundational support for student learning during class time and the lecturer spent more time working on higher levels of learning with students. During class time the students were allowed to do group discussions and do presentation of their in-class activities. Towards the end of the lesson the students were administered to write a tutorial test and submission were done before end of lesson. Similar to the traditional lecture format, the course was divided into two modules and in each module the students were allowed to write two tests.

3 Results and Discussion

To answer the research question: *Is there a significant difference of student performance scores attributed to teaching method variable?* the means, standard deviations of student performance scores for the four tests are calculated for control and experimental groups according to the group variable – teaching method. The tests are described as oa1/TEST A1, oa2/TEST A2 for test written in the first module and ob1/TEST B1 and ob2/TEST B2 for test written in the second module. Figure 1 shows the box plot of the student performance scores for the two years considered in the study. The distribution of the student performance scores can be clearly seen that they are different for the two groups. In the box plot for the first tests taken by the two groups i.e. OA1, the median score sits at approximately 25 mark for students who experienced traditional classroom model, whereas the median for the scores of students who experienced flipped classroom model sits above approximately 50 mark. It can be clearly seen that the median mark for students who experienced flipped classroom model is higher than for students who experienced traditional classroom model. This generally indicates that the majority of students who experience flipped classroom model outperform students who experience traditional classroom model.

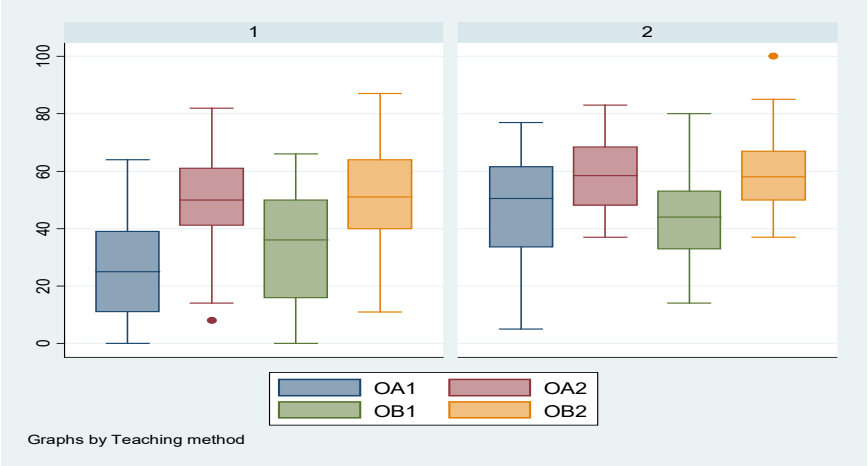

Figure 1: Distribution of students performance scores for the different teaching methods

Table 3 shows the means of student performance scores for the four tests. In the table the means are calculated according to the teaching method with 1 indicating traditional classroom model (year = 2019) and 2 indicating flipped classroom model (year = 2022). Table 3 and reveals that there are clear differences in means of the student performance scores attributed to the group variable for control and experimental groups. For all the test results in both modules it is clear that the means of student performance scores are higher in flipped classroom model than in traditional classroom model. This finding supports results from Wei et al, 2020 who indicated that in flipped classroom model student achieve higher performance scores than in traditional classroom model. To show the statistically significant difference between means, t-test analysis was done for the two groups. The two sample tests were conducted for unpaired data since the students were different for each year considered. The Welch's formula was also used to calculate the approximate degree of freedom for the test since unequal variances for the unpaired data was assumed. Table 3 shows the t-test results of the four tests written by the two groups considered in this case study.

Table 3: t-test results of the four tests

Test	**Sample size**	**Teaching Method (year)**	**Mean**	**Standard deviation**	**t-test value Pr|T| >|t|**
Test A1	71	Traditional (2019)	26.14	17.18	0
	44	Flipped (2022)	47.45	16.56	
Test A2	71	Traditional (2019)	50.30	15.12	0.0020
	44	Flipped (2022)	58.61	12.73	
Test B1	71	Traditional (2019)	32.51	18.37	0.0009
	44	Flipped (2022)	43.52	13.35	
Test B2	71	Traditional (2019)	50.96	19.2	0.0220
	44	Flipped (2022)	58.58	12.91	

In Table 3, the means are statistically different at any level greater than 0% and 0.2% for Test A1 and Test A2 respectively. This means that there is statistically significant different between

the means of the two groups for the significance level of p=0.05 chosen for this research study. The null hypothesis is therefore rejected in this case. The student performance scores in flipped classroom model are greater than in traditional classroom model. Similarly, the means for the two groups are statistically different at any level greater than 0.09% and 2.20% for Test B1 and Test B2 respectively. The students who experienced flipped classroom model still outperform students who experienced traditional classroom model. These results are consistent with results from several research studies done by other researchers using different settings [Unal & Aslihan, 2017; Wei et at, 2020; Terri et al, 2014]. In this research study, the improvement of student performance scores in the flipped classroom model could be due to the out-of-class activities that were given to students which enabled them to ask relevant questions when they engaged with the facilitator in class. Previous research studies have also suggested that there is a positive correlation between motivation and performance and thus flipped classroom model might have motivated and increased the feeling of curiosity in this innovative teaching practice for students [Anold-Garza, 2014; Covill & Cook, 2019; Terri et al, 2014]. Moreover, the teacher had more time in class to engage with students in discussion over different engineering concepts and thus low performing students would have been able to correct possible misunderstanding of different processes. Writing of a tutorial test towards the end of the lecture would have also helped student to self-reflect on their understanding of different engineering concepts that would have been presented and/or discussed during lecture time. The availability of pre-recorded video lectures at my institution allowed me an opportunity to investigate the usefulness of flipped classroom model in which students were allowed to watch the same lecture provided to the control group which experienced traditional classroom model.

This research study cannot be adopted in its entirety as it has several limitations. Firstly, opinions vary on what constitutes a flipped classroom model although it is fairly clear that its primary tenet is focusing on intensification of interactive classroom learning activities as well as ensuring that students have active pre-class preparation. The second limitation is that the students used in this research study are drawn from one institution and they are different for each group. Thirdly, the research study was designed to evaluate the effectiveness of flipped classroom model versus traditional classroom model only for a specific third year electrical engineering course. However, the findings from this research study provide the first direct comparison of traditional versus flipped classroom model for a third year electrical engineering course subjected with the same instructor, course material, lectures and tests.

4 Conclusion

An interactive learning environment enables students to become involved in the learning process, gain more knowledge, and become more satisfied. It is a two-way communication between the facilitator and the student, and it therefore encourages input from both sides. A case study related to the use of interactive teaching practice for teaching engineering at a South African university was conducted. The study investigated the effectiveness of traditional classroom model versus flipped classroom model involving interactive learning strategies in a third year electrical engineering module. The results from the study showed that students who experienced flipped classroom model outperform the students who experienced traditional classroom model. This finding can impart confidence in engineering teachers who want to use modern interactive teaching strategies, in particular flipped classroom model, as an improvement in their teaching practices. In addition, the findings also reveal that teachers in engineering courses need to have adequate training to use new teaching strategies especially those that involve new technology tools such as a flipped classroom model. It is further recommended that universities need to provide adequate technology tools to help their engineering teachers to better prepare for needed materials required for new innovative

teaching strategies such as flipped classroom model. In conclusion, this finding supports that teaching methods that include interactive learning strategies such as a flipped classroom model can be effective ways of disseminating key engineering concepts to university engineering students.

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