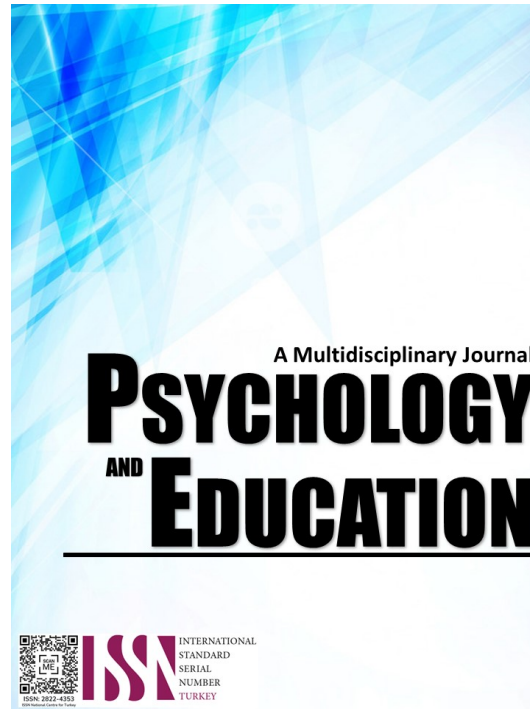


# **IMPACT OF THE FLIPPED CLASSROOM ON CIVIL ENGINEERING STUDENTS' LEARNING OF DIFFERENTIAL CALCULUS**



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# Impact of the Flipped Classroom on Civil Engineering Students' Learning of Differential Calculus

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## Abstract

The flipped classroom method reverses a class's traditional lecture and homework elements. In a flipped classroom, students watch and listen to recorded lectures and read course materials before class. As an intervention, this utilizes the mastery learning model, which entails students' understanding of the topic before proceeding to the next topic. This One-Group Pretest-Posttest Experimental study aimed to determine the effectiveness of flipped classroom approach in teaching Differential Calculus among first-year Civil Engineering students of the University of Antique. Forty-two (42) first-year Civil Engineering students participated in the study during the second semester of the Academic Year 2023-2024. The researcher administered a pretest-posttest to determine the students' problem-solving skills and performance. The researcher also optimized collaborative learning through assignments given inside the classroom. After the posttest, the student's attitude towards using flipped classrooms is "Very High." As 21st-century learners, it is perceived that engineering students have high regard for flipped classroom learning. Posttest results showed that applying the flipped classroom approach improved the students' capacity to solve problems and mastery of solving calculus problems. Therefore, the flipped classroom method effectively enhances students' problem-solving skills and performance in Differential Calculus.

**Keywords:** Philippines, Flipped Classroom, Differential Calculus, Recorded Lecture, Civil Engineering Students'

## Introduction

The flipped classroom is a teaching style that flips a class's usual lecture and homework components. Before class, students in a flipped classroom view or listen to recorded lectures, read course materials or engage in other learning activities. During class, the teacher facilitates learning and guides students through collaborative activities, problem-solving exercises, and conversations to apply in the pre-class learning. The flipped classroom method seeks to move the emphasis of classroom time away from passive listening and toward active learning. By giving pre-class resources, students can learn based on their pacing and have ample time during class to participate in interactive and collaborative activities. This strategy can assist teachers in locating potential areas of student difficulty and offering focused support. The popularity of the flipped classroom approach has grown in recent years due to the expansion of online learning materials, including video lectures and interactive tutorials.

The primary goal of this scholarly work is to examine how the flipped classroom approach affects the teaching of Differential Calculus and reducing anxiety levels among first-year Civil Engineering students. Consequently, Mathematics is considered a broad and complex subject in higher education and is often cited as the most challenging course in engineering licensure examinations, given that it is the foundation

of all engineering programs. Calculus is categorized as a challenging course with little relevance to real-life situations. Some students may lack the necessary mathematical skills to pass such courses, resulting in anxiety and fear of failure. Mathematics instructors require help finding an effective teaching approach to improve the learning environment. Therefore, teachers should develop innovative strategies to engage and motivate students as part of their learning acquisition.

## Research Questions

This study focused on employing the flipped classroom approach as an intervention to make first-year civil engineering students improve their problem-solving skills in Calculus. With this, the researcher determined the impact of the flipped classroom in teaching Differential Calculus. Explicitly, this study delved answers to the following queries:

1. What are the mean pretest and posttest scores of the students in Differential Calculus of the experimental group?
2. What is the attitude of the students toward the flipped classroom approach?
3. Is there a significant difference between the respondents' pretest and posttest results utilizing flipped classrooms in teaching Differential Calculus?

## Literature Review

As Asia has taken the lead in flipped learning studies, the flipped learning approach is primarily used in higher education (Birgili et al., 2021). The Flipped classroom has been cited by Granata (2014), stating that educators have ample instructional pedagogies on Web-aided instructional materials that allow teachers to utilize class hours employing interactive activities with students rather than using the lecture method. Applications of the flipped classroom comprise digital storytelling, educational games, problem-based learning, and peer tutoring (Berrett, 2012; Felder, 2012; Herreid & Schiller, 2013). Technology usage in college, university, and K-12 classrooms makes flipped learning a rising instructional approach as technological breakthroughs continue transforming teaching (Brewer & Movahedazarhouli, 2018). Strayer (2012) emphasized that blended learning classrooms, which employ technology to transfer lectures outside of the classroom and learning activities to move practice with concepts inside the classroom, result from recent technological advancements.

The principle behind the flipped classroom is that teachers can spend ample time in the classroom working with students who need their support, and students may work together to solve difficulties, rather than sitting at home alone with work they may not understand and no one to ask for help (Nwosisi et al., 2016). Active learning activities increase millennial participation (Bhakti et al., 2019). Furthermore, active learning requires technology support; thus, the flipped classroom is proposed as one of the pedagogical ways to supplement the entire learning process. According to Al-Samarraie et al. (2020), using flipped classrooms in many disciplines is primarily encouraged to improve students' engagement, metacognition, attitude, performance, understanding, and achievement, among other learning outcomes. Educators have identified the flipped classroom as an innovative and effective instructional strategy (Hwang et al., 2015). According to Fernández-Martín et al. (2020), the deployment of Flipped Classroom improved students' understanding and attitudes toward mathematical concepts and discipline in most situations. Several challenges were identified in the flipped classroom application, such as technological issues, editing recording skills, and time commitment (Umam et al., 2019). Furthermore, students in the inverted classroom were less satisfied with how the classroom structure orientated them to the course's learning requirements; however, they grew more open to cooperative learning and innovative

teaching methods (Strayer, 2012). As such, the researcher proposes to conduct an experimental investigation on using flipped instruction in Mathematics, specifically in Calculus, among civil engineering students.

## Methodology

Forty-two (42) first-year civil engineering students participated in this study, which used a One-Group Pretest-Posttest Experimental Design. The instruments used in the flipped classroom were validated on the topic of Differentiation, specifically on calculating the derivative of a function using a) the general power rule and basic differentiation rules, b) the sum and difference rule, c) the product and quotient rule, and d) the chain rule. A pilot test was conducted to determine the reliability of the instrument. According to the findings, the Cronbach's Alpha ( $\alpha$ ) values for the Student Attitude in Flipped Classroom and the Differential Calculus instruments are 0.73 and 0.78, respectively, indicating the internal consistency is "Acceptable." A table of Specifications (TOS) was created, and following the trial run, item analysis was carried out. Ferguson (1979) pointed out that through item analysis, high validity and reliability could be attained. Moreover, the result of the item analysis led to the revision of a single item in the test instrument. This study observed three stages: preparation, instruction, and evaluation (Pavanelli, 2018). Downloaded video lectures from Youtube.com on Differential Calculus were used in this study. Also, the questionnaire was used to assess students' attitudes towards the Flipped Classroom as an intervention using a five-point Likert scale. Ten (10) Likert scale questions were created to assess the impact of flipped Classroom learning delivery. Each question had the following response options: strongly agree, agree, neutral, disagree, and strongly disagree. Descriptive statistics involving mean and standard deviation were utilized to assess the individuals' attitudes regarding flipped classes. The information gathered from the respondents was collated, classified, evaluated, and interpreted. Individual posttest results were also used to assess learning efficacy.

## Result

An appraisal was made to determine its efficacy via posttest scores and the student's satisfaction with the flipped classroom approach. This section covers the result of students' performance before the intervention,



the result of students' performance after the intervention, the attitude of the students toward the flipped classroom, and the significant difference between the pretest and posttest outcomes of the respondents utilizing flipped classroom in teaching Calculus in Mathematics using Statistical Package for the Social Sciences version 17 (SPSS v.17).

### Mean Pretest and Posttest Scores of the Students in Calculus

Table 1 provides information on the student's academic performance before and after the intervention regarding sex, mean, and standard deviation.

Table 1. Mean Pretest and Posttest Scores of the Students

Category	Sex	N	Mean	SD
Pretest Experimental	Male	24	77.00	7.460
	Female	18	74.83	5.793
Posttest Experimental	Male	24	79.92	7.558
	Female	18	78.06	5.011

Figure 1. .

Table 1 shows that the mean posttest scores of the male students increase from 77 to 79.92. Also, the female students' mean posttest scores increase from 74.83 to 78.06. Moreover, there is a 3.79% increase in the score of male students. At the same time, there is a 4.32% increase in the scores of female students. In several disciplines, using flipped classrooms is promoted primarily to improve students' engagement, performance, knowledge, and achievement, among other learning objectives. In most cases, implementing flipped classrooms enhanced students' understanding and attitudes toward mathematical ideas and discipline. Overall, the flipped classroom improved students' calculus learning performance.

### Students' Attitude Towards Using Flipped Classroom

Table 2 provides information on the student's attitudes toward the flipped classroom. The questionnaire includes ten (10) statements on the significance of instructional videos in understanding the concepts and principles in Differential Calculus; the accessibility of instructional videos; instructional videos make students highly productive in class; active in

interaction; open communication with other students and the instructor; the role of the instructor in helping the students finish the activity which is motivating since videos can be replayed and encourage mastery; and collaborative learning in teaching mathematics.

Table 2. Students' Attitude Towards Using Flipped Classroom

	Statement	Mean	SD	Description
1	Instructional videos help me to better comprehend the concepts and principles in Calculus.	4.24	0.96	Very High
2	The instructional videos are accessible for me to learn during my spare time.	4.17	0.76	High
3	The instructional videos enable me to be highly productive in class.	3.95	0.82	High
4	It encourages more active interaction in class.	4.38	0.82	Very High
5	It opens communication between my instructor and me.	4.36	0.62	Very High
6	To finish my classroom activity, my instructor help me to finish it.	4.38	0.73	Very High
7	The flipped classroom approach is motivating and a fun way to learn Mathematics.	4.45	0.74	Very High
8	To better understand the topic, I have watched the video many times.	4.40	0.80	Very High
9	It encourages collaborative learning.	3.71	0.67	High
10	The university should utilize the Flipped Classroom Approach in teaching Mathematics.	4.12	0.67	High
Total		4.22		Very High

Figure 3. .

The table reveals students' attitudes toward flipped classrooms with an overall mean of 4.22, interpreted as "Very High." The statement "The flipped classroom approach is motivating and a fun way to learn Mathematics" (Mean = 4.45) receives a "Very High"



level of students' attitude towards the flipped classroom. Items such as "Instructional videos help me to better comprehend the concepts and principles in Calculus," "It encourages more active interaction in class," "It opens communication between my instructor and me," "To finish my classroom activity, my instructor help me to finish it"; "The flipped classroom approach is motivating and a fun way to learn Mathematics," and "To better understand the topic, I have watched the video many times" with means of 4.24, 4.38, 4.36, 4.38, 4.45, and 4.40 respectively, obtain a "Very High" level of students attitude towards the flipped classroom. On the other hand, the items "The instructional videos are accessible for me to learn during my spare time," "The instructional videos enable me to be highly productive in class," "It encourages collaborative learning," and "The university should utilize the Flipped Classroom Approach in teaching Mathematics" with means of 4.17, 3.95, 3.71, and 4.12 respectively obtain a "High" level of students' attitude towards the flipped classroom intervention. Thus, it is perceived that 21st-century learners have high regard for flipped classroom learning.

**Significant Difference Between Pretest and Posttest Results of the Respondents Utilizing Flipped Classroom**

Table 3 reveals the significant difference between pretest scores, posttest scores, mean, standard deviation, t – value, P-value, decision, and interpretation.

Table 3. *Significant Difference of the Pretest and Posttest Scores of the Experimental Group*

Pair	N	Mean	SD	t-value	P-value	Remark
Pretest Experimental	42	76.07	6.805	72.444	.000	Significant
Posttest Experimental		79.12	6.582	77.898		

Figure 4. .

The result shows a significant difference between the pretest and the posttest of civil engineering students in Differential Calculus. The mean of the posttest result (M=79.12) is significantly 4% higher than the mean of the pretest (M=76.07) result. As a result, there is a change in the student's behavior in Calculus regarding academic performance in Mathematics. With this, the null hypothesis is rejected in favor of the research

hypothesis; subsequently, P-value is less than 0.05. Furthermore, the result means that there is a significant difference between the pretest and the posttest scores of the experimental group. Using flipped classrooms in teaching Mathematics, specifically in Differential Calculus, has positively affected student achievement.

**Discussion**

The scholarly work's main objective is to investigate how the flipped classroom method influences differential calculus instruction and anxiety among first-year Civil Engineering students. With this, the researcher determined the impact of the flipped classroom in teaching Mathematics. Given that it is the basis of all engineering programs, mathematics is therefore regarded as a vast and complex subject in higher education. It is frequently cited as the most challenging course in engineering licensure examinations. Thus, this analysis utilized One-Group Pretest-Posttest Experimental approach to 42 first-year civil engineering students to determine the flipped classroom's effectiveness in the student's academic performance in learning differential calculus. Moreover, the results of the study demonstrated that flipped classes positively influenced first-year civil engineering students' academic performance in Differential Calculus.

**Conclusion**

The flipped classroom approach is an effective way to engage students and improve learning outcomes. Teachers can free up class time for more interactive and engaging activities, such as discussions, group work, and hands-on exercises, by providing students with pre-recorded lectures or printed materials to review before class. This approach can also help students who struggle with traditional classroom settings, as they can review independently and asynchronously. Furthermore, the posttest scores were higher than the pretest scores after the intervention was conducted. The null hypothesis was rejected in favor of the research hypothesis, which indicates a significant difference between the pretest and posttest scores of the experimental group. Through verified tests and questionnaires, the study proved that flipped classrooms favorably influenced first-year civil engineering students' academic performance in Differential Calculus.

Ultimately, the flipped classroom approach's success

will depend on various factors, including the specific needs and learning styles of students, the subject matter being taught, and the teaching methods used by the instructor. As with any teaching approach, it is important to continually evaluate and adjust the flipped classroom model to ensure that it is meeting the needs of all students and helping them achieve their learning objectives. Additionally, based on the study's findings, it is strongly suggested that flipped classrooms should be utilized in teaching other challenging Mathematics topics. Educators may consider incorporating the flipped classroom approach into their standardized teaching methods while exploring other innovative pedagogies suitable for 21st-century education. Future researchers of flipped classrooms are encouraged to customize video lessons and make them more engaging and appealing to students. Other researchers may also explore and assess the effects of integrating the flipped classroom method in teaching various subjects, not only Mathematics.

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