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Research Article

Impact of the flipped classroom on academic achievement, motivation, and engagement: A higher education case study

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ABSTRACT

As we examine the pandemic's impact on higher education, we can see that many previously traditional teaching and learning frameworks have been invalidated, and the need for new teaching and learning approaches has increased. This indicates that the traditional frameworks for higher education may no longer be effective. Consequently, there is a need for a new approach, and the flipped classroom model could be a suitable solution for the future of higher education after the pandemic subsides. This study measured the impacts of the flipped classroom method on students' academic achievement, engagement, and motivation in the introduction to data analysis course (STA113), which is a compulsory general course for all undergraduate students at Ajman University in the United Arab Emirates. A quasi-experimental design involved 71 students divided into two groups: an experimental group (N = 36) using the flipped classroom method and a control group (N = 35) receiving traditional instruction. Educational videos and e-content were provided via Moodle. A cognitive achievement test and a survey assessed students' motivation and engagement. Results showed statistically significant differences favoring the experimental group, with these students demonstrating greater improvement in skills, knowledge, and motivation compared to those in the control group. This research contributes to the literature by providing evidence that the flipped classroom method can enhance undergraduates' academic achievement, motivation, and understanding of STA113 topics.

Keywords: flipped classroom, achievement, engagement, motivation, higher education

INTRODUCTION

The COVID-19 pandemic is one of the most significant crises in modern history, impacting every facet of life globally. Among the most affected sectors was education, which had to quickly adapt to alternatives to traditional teaching methods (Fernandez & Shaw, 2020; Williamson et al., 2020).

With the rise of technology and distance learning, e-learning platforms have gained popularity in higher education, enabling teachers and students to maintain communication remotely (Eltahir, 2019). The pandemic has disrupted traditional educational frameworks, revealing that methods once effective may no longer suffice in the current context (Allen et al., 2020).

Research Background

The transition from conventional classrooms to digital learning environments has spurred interest in innovative pedagogical approaches (Cevikbas & Kaiser, 2020), with the flipped classroom model (FCM) emerging as a notable example. This model reverses the traditional teaching dynamic by having students

engage with instructional content–such as lecture videos–outside of class, thereby freeing up in-class time for interactive, student-centered activities (Eltahir, 2018; Talbert, 2017). The flipped classroom has gained traction in recent years, particularly as digital video and online learning platforms like Khan Academy, Coursera, edX, and Udemy have become central to the educational experience (Allen et al., 2020). This pedagogical shift is underpinned by constructivist learning theories, which integrate technology with a collaborative, supportive learning philosophy, has facilitated the emergence of the flipped classroom as an evolution of the blended learning model (Xu & Shi, 2018). This approach allows universities and schools to adopt modern teaching methods, addressing contemporary challenges while equipping students with new skills (Goedhartet al., 2019).

In this approach, learning becomes an active process as students collaborate, share ideas, and participate in class discussions, fostering continuous engagement (Alsalhi, 2020). Emphasizing results over mere attendance, the flipped classroom encourages critical thinking and collaborative knowledge-building, creating an empowered learning environment (Berrett, 2012; Brame, 2013; Estrada et al., 2019; Hwang & Wang, 2015). However, the effectiveness of instruction in a flipped classroom depends on more than just converting educational content into digital formats. It also requires a deep understanding of cognitive theories, student-centered learning, and the role of critical thinking in education (Babiker, 2015).

Research Problem

Despite the growing adoption of the FCM, there remains a lack of comprehensive understanding of its impact on student outcomes, particularly in the context of higher education. The challenge lies not only in effectively implementing this model but also in ensuring that it meets its intended goals of enhancing academic achievement, student engagement, and motivation. Traditional lecture-based instruction, though still prevalent, may not align with the needs of today's learners, who require more interactive and personalized learning experiences. Therefore, it is crucial to investigate whether the FCM can address these needs more effectively than conventional approaches.

Research Gap

While existing studies have explored various aspects of the FCM, there is a noticeable gap in research specifically focused on its application in courses related to data analysis. Furthermore, the extent to which this model influences student engagement, motivation, and academic achievement in such courses remains underexplored. Previous research has often focused on general education or specific disciplines like STEM, but there is limited empirical evidence on the effectiveness of flipped classrooms in the context of data analysis education.

Purpose of the Study

To address this gap, the present study aims to evaluate the influence of the FCM on students' academic performance, engagement, and motivation in an introductory data analysis course (STA113). By examining these factors, this research seeks to contribute to the broader understanding of how flipped classrooms can be optimized to improve learning outcomes in higher education.

Significance and Goals of the Research

The significance of this research lies in its exploration of the flipped classroom approach and its potential impact on student outcomes, specifically in the context of higher education. While the FCM is not entirely novel, its application in specific courses, such as introductory data analysis (STA113), requires further investigation to better understand its effects on academic achievement, motivation, and engagement.

This study aims to contribute to the existing body of literature by focusing on how the flipped classroom approach can influence these key educational outcomes in higher education settings. The primary goal is to examine whether the FCM can enhance students' learning experiences and outcomes compared to traditional teaching methods. By doing so, the study seeks to provide insights that may help educators adopt more effective teaching strategies that resonate with the needs and preferences of contemporary students.

Additionally, this research emphasizes the importance of motivation and engagement–two critical factors in the learning process. According to the self-determination theory (SDT), students are more likely to succeed

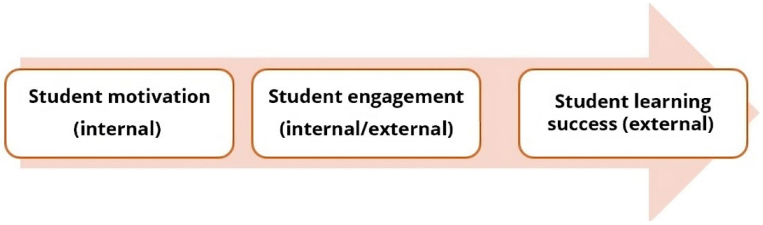

Figure 1. Relationship between motivation, engagement, and student success (Source: Authors)

when they are motivated and actively engaged in their learning activities (Gayeski, 2022), as outline in **Figure 1** (Adams et al., 2017; Fredricks et al., 2004). By examining these dimensions within the flipped classroom context, the study aims to shed light on how this approach can support students' academic success.

The Questions of Study

The study questions were defined by decomposing the research goals:

Q1: What are the effects of the flipped classroom approach on undergraduates' academic achievement in the STA113 course in higher education?

Q2: How does the flipped classroom method influence undergraduates' motivation to learn STA113 in higher education?

Q3: What impact does the flipped classroom method have on undergraduates' engagement in learning STA113 in higher education?

Q4: Are there significant differences in learners' motivation levels in the flipped classroom based on gender, academic performance (CGPA), and academic level?

Q5: Are there significant differences in learners' engagement in the flipped classroom based on gender, academic performance (CGPA), and academic level?

Research Objective

Based on the research questions, the following objectives have been proposed:

- Explore the concept and significance of the FCM within the educational process, focusing on its practical application rather than establishing a theoretical foundation.
- Assess the impact of the flipped classroom approach on student motivation and engagement in higher education, particularly in the context of an introductory data analysis course (STA113).
- Investigate higher education students' attitudes toward the flipped classroom and use their feedback to inform recommendations for its effective implementation in future studies.

LITERATURE REVIEW

Core Concept

Academic achievement

Based on Steinmayr et al. (2014), educational achievement measures how well a student has accomplished specific goals. The definition of academic achievement depends on how it is measured. A number of criteria can be used to measure academic achievement, including knowledge acquired through procedural and declarative learning, grades, or performance on educational achievement tests.

Motivation

Motivation refers to the psychological processes that drive and guide behavior towards a goal (Cofer & Appley, 1964). It involves the activation of the individual's internal resources, such as thoughts, emotions, and desires, to initiate and sustain behavior. An individual's motivation is the force that drives them to act a certain way. It is impacted by in and outer factors including beliefs, values, and needs (Plant & Devine, 1998). Motivation depends on the individual's goals and the situation they are in, and it can range from intense to

persistent. Motivation has an effective role in human behavior and is vital to achieving success and fulfilling one's potential (Cofer & Appley, 1964; Eltahir et al., 2021).

Engagement

It is a psychological framework that explains how people become motivated, invested, and committed to certain activities, goals, or tasks (Kearsley & Shneiderman, 1998). In engagement theory, people are engaged when they are fully absorbed, energized, and focused on an activity or task that is challenging, meaningful, and aligned with their interests. A core principle of engagement theory is that undergraduates have to act together and perform meaningful tasks in order to learn. According to Kearsley and Schneiderman (1998), it serves as a model for incorporating technology into educational processes. Technology can facilitate interactions that would be challenging to achieve otherwise (Kearsley & Shneiderman, 1998)

Flipped classroom

Flipped class is a teaching method that involves reversing the traditional order of instruction. Within such classes, undergraduates are introduced to new concepts and materials outside of class time through online videos, readings, or other digital content files (Bergmann & Sams, 2014). They are expected to review these materials before attending the class, where they engage in collaborative and interactive activities with their peers and teachers to expand their content understanding (Bergmann & Sams, 2012). Bishop and Verleger (2013) explain the flipped class approach as a mixture of group-based interactive learning activities conducted in the classroom and computer-based individual instruction that takes place outside of the classroom environment. Such class method lets undergraduates learn at their own effort, focus on areas they find challenging, and engage in active learning during class time (Nouri, 2016).

Theoretical foundations of the FCM

The FCM is grounded in four main educational theories: constructivist learning theory, active learning theory, pedagogical differentiation theory, and SDT. These theories collectively provide a robust framework for understanding how the flipped classroom approach can enhance student learning and engagement in higher education.

Constructivist learning theory: Constructivism, drawing from the works of Bruner (1962, 1979), Vygotsky (1962, 1978), Piaget (1970), and Papert (1980, 1993), posits that learners construct knowledge through their interactions with the environment, including social interactions with peers and teachers (Bruner, 2009; Schunk, 2012; Vygotsky, 1978). Constructivists argue that education has traditionally been biased towards objectivism, viewing undergraduates as passive recipients of knowledge (Biggs, 1996; Bruner, 2009; Dick & Carey, 2001). Consequently, mentors have to create environments that facilitate knowledge construction and act as coaches, facilitators, or even partners with learners.

In the flipped classroom, students engage with instructional content independently before class, allowing them to construct their understanding based on prior knowledge. This approach shifts the focus from passive reception of information to active engagement, where students apply, analyze, and expand on what they've learned during in-class activities (Hamdan et al., 2013).

Active learning theory: Active learning theory emphasizes the importance of engaging students in activities that require them to think critically, discuss, and apply knowledge rather than passively receive information (Bonwell & Eison, 1991). The FCM embodies this theory by reallocating classroom time from lectures to interactive activities, such as discussions, problem-solving tasks, and collaborative projects (Bishop & Verleger, 2013). This hands-on approach helps students deepen their understanding of the material and retain information more effectively.

Pedagogical differentiation theory: Pedagogical differentiation theory advocates for tailoring instruction to meet the diverse needs, interests, and abilities of students (Tomlinson, 2001). The FCM facilitates this by allowing students to learn at their own pace outside of class, with in-class time dedicated to personalized support and differentiated instruction (Bergmann & Sams, 2012). This approach ensures that students with varying levels of prior knowledge and learning styles receive the guidance they need to succeed.

SDT: SDT focuses on the role of autonomy, competence, and relatedness in fostering intrinsic motivation (Deci & Ryan, 1985). The FCM promotes autonomy by giving students control over when and how they engage with learning materials. It also enhances competence by allowing students to engage deeply with content and receive timely feedback during class (Ryan & Deci, 2000). The collaborative nature of in-class activities fosters a sense of relatedness among students, further supporting their motivation to learn (Chen et al., 2016).

Related Studies

The impacts of flipped classes on undergraduates learning outcomes, level of achievement and engagement have been examined in several studies (Awidi & Paynter, 2019; Busebaia, & John, 2020; Elmaadaway, 2018; Kazanidis et al., 2019; Lopes & Soares, 2018; Loveys & Riggs, 2019). It has been shown that such a classroom identifies positive effects on the acquisition of knowledge and advancement of student learning.

Several studies have placed their focus on the impact of this method regarding learner experience (Awidi & Paynter, 2019; Busebaia & John, 2020; Kazanidis, et al., 2019; Lopes & Soares 2018). For example, Awidi and Paynter (2019) examined the impact of a flipped classroom method on the learning experience of undergraduate biology learners. Their findings were that, at the undergraduate level, students were delighted with certain aspects of the flipped approach. It was hence concluded that further enhancing the flipped design by including recorded lectures and in-class sessions could further enhance student learning.

Similarly, Kazanidis et al. (2019) conducted a study to assess the efficiency of a flipped classroom method in instructing subjects related to instructional media design. The study compared learner's academic satisfaction and performance with training between traditional lecture-based instruction and the model of flipped class. The findings of their quasi-experimental study showed significant differences in terms of training pleasure and academic achievement, the experimental group outperformed the control group by a large margin.

Moreover, research by Elmaadaway (2018) study, the flipped classroom method resulted in augmented engagement in comparison to traditional face to face teaching. Loveys and Riggs (2019) also found higher engagement levels and decreased failure rates in undergraduate science courses using the flipped classroom method. However, most of the previous literature has found that the results were inconclusive for natural, applied sciences and formal sciences disciplines that requiring real-life practice (Bredow et al., 2021; Cheng et al., 2019; Rothman, 2022; Strelan et al., 2020; Tang et al., 2020; Van Alten et al., 2019). Some studies also indicated that there is no compelling proof of the effect of flipped learning on establishing lifelong learning and other 21st century skills in undergraduate education such as collecting, analyzing, and interpreting data (O'Flaherty & Phillips, 2015).

Van Alten et al. (2019) carried out a meta-analysis including 114 studies from four major disciplines (sciences, humanities, social sciences, and recognized sciences) to identify the relationship between flipped classrooms and non-flipped classrooms in secondary and post-secondary education. Their study figured out a slight significant impact on learning outcomes, whereas no impact on learner's satisfaction with the learning environment. Furthermore, they figured out significant heterogeneity among studies. They found that very few studies have investigated the potential impact of flipped classes in specific academic disciplines. They noted that some academic disciplines could be better proper to adopt flipped classrooms, as studies in various disciplines have shown positive and negative undergraduates' perceptions of flipped classrooms.

The Cheng et al. (2019) meta-analysis study compared 55 studies published between 2000 and 2016 that used flipped education with traditional classrooms. In general, the study figured out a statistically significant impact size for flipped classrooms. The effect varied from low to high depending on the subject area. These areas include mathematics, sciences, health, engineering, social sciences, arts, humanities, and business. Strelan et al. (2020) performed a comprehensive meta-analysis to assess the impact of the flipped class model on undergraduate's performance in various disciplines and educational levels, compared to traditional methods of teaching. Their studies included 198 studies, 174 at the higher education level, 21 at the secondary level, and three at the elementary level. The study generally found that flipping the classroom had a moderately positive effect on learner performance and it was advantageous irrespective of discipline, as the

effect sizes ranged from weak for natural and applied sciences that require practical application such as information technology too strong for the humanities.

Additionally, Tang et al. (2020) conducted a study to assess the effectiveness of different online teaching methods, comparing a proposed hybrid model of online and flipped learning with other online and traditional teaching approaches. The study utilized a questionnaire aimed at engineering undergraduates at Chengdu University of IT. The research findings illustrated that while undergraduates were generally displeased with online education, combining online teaching with the flipped education model led to advances in students' learning outcomes, attention, and course evaluation.

Lastly, Rothman's (2022) study compared the perceptions and performance of learners in a flipped classroom versus traditional lecture on an international relations theory course. A survey was used to measure student reactions and perceptions to flipped classes in comparison to traditional classrooms and a post-test was adopted to measure the effects of different teaching methods on student performance on exams. Flipped classrooms were found to be highly preferred by students, while statistical analysis did not indicate a correlation between these techniques and performance outcomes.

Despite the extensive research on FCM, several gaps remain that the present study aims to address. First, there is a lack of studies focusing on the application of FCM in specific disciplines such as data analysis in higher education. Most existing research has concentrated on more general subjects or STEM fields, leaving areas like data analysis underexplored. Furthermore, while many studies have examined the impact of FCM on academic achievement and engagement, fewer have considered the influence of variables such as gender, academic performance (CGPA), and academic levels on these outcomes.

The present study seeks to fill these gaps by investigating the effects of FCM on student engagement and motivation in an introductory data analysis course (STA113) at the higher education level. By exploring these specific contexts and variables, this research aims to provide new insights into the effectiveness of FCM and offer recommendations for its implementation in similar academic settings. This study will contribute to the broader understanding of FCM's potential and limitations, particularly in subjects that require analytical thinking and data interpretation, where its application has not been extensively studied.

METHOD

Participants

A total of 71 undergraduate students from three colleges enrolled in two sections of STA113 during the summer semester (6 weeks) of the academic year 2022-2023 participated in this study. The first section consisted of 36 students considered an experimental sample and the second one was the control sample with 35 students.

Demographic Information

The participants ranged in age from 18 to 24 years old. Most students had some degree of exposure to technology, with varying levels of computer literacy. Approximately 90% of the participants reported regular use of mobile phones, and 85% had access to the internet outside the classroom, indicating a relatively high level of technological accessibility. Given that the educational programs were conducted in English, participants' proficiency in English was also considered. On average, students had intermediate to advanced English language skills, but a minority (around 12%) were identified as having weaker English proficiency, which could influence their motivation and engagement in the course. **Table 1** show the participants' details.

Research Design

For the purpose of this study, a quasi-experimental approach was selected as it was deemed appropriate for achieving the research objectives. Although this study involves an intervention with both experimental and control groups, it does not include random assignment of participants to these groups, which is a key characteristic that differentiates quasi-experimental from true experimental designs. In this study, participants were already grouped based on their enrolment in specific sections of the STA113 course.

Table 1. Data of participants

Group	Number		Percentage (%)	Total
Empirical	36		51.00%	(71) 100%
Control	35		49.00%	
Gender	Female (37)		52.00%	
	Control	Empirical		
	21	16		
	Male (34)		48.00%	
	Control	Empirical		
	14	20		
Students' CGPA	Below 2.0	3	8.33%	(36) 100% empirical group
	2.0-2.4	5	13.89%	
	2.5-2.99	10	27.78%	
	3.0-3.5	12	33.33%	
	3.6-4.0	6	16.67%	
Students' age	18-20	24	66.66%	
	21-24	12	33.33%	
College	Law	8	22.20%	
	Humanities	16	44.40%	
	Mass communication	12	33.30%	
English proficiency levels	Beginner	4	11.11%	
	Intermediate	12	33.33%	
	Advanced	20	55.55%	
Computer skills	Fundamental	2	5.55%	
	Intermediate	8	22.22%	
	Advanced	26	72.22%	
Academic levels	Freshman	4	11.10%	
	Sophomore	8	22.20%	
	Junior	14	38.90%	
	Senior	10	27.80%	

Therefore, the assignment to the control (traditional lecture) and experimental (flipped classroom) groups was non-random.

The research design for this study involved a comparative analysis of traditional lecture-based teaching and the FCM to evaluate their effects on student motivation and engagement in an introductory data analysis course (STA113). The design consisted of the following steps:

1. **Pre-test**: At the beginning of the study, all participants took a pre-test to assess their baseline knowledge of data analysis. This ensured that any differences observed in the post-test could be attributed to the teaching method rather than pre-existing knowledge differences.
2. **Intervention**: Participants were divided into two groups:
   - The control group received traditional lecture-based instruction.
   - The experimental group experienced the FCM, which included pre-class video lectures and in-class activities focused on application and analysis.
3. **Questionnaire on motivation and engagement**: After the intervention, both groups completed a questionnaire designed to measure their motivation and engagement levels. This questionnaire, developed by the researchers and validated by experts, used a Likert scale to capture students' perceptions of the teaching methods.
4. **Post-test**: Finally, all participants took a post-test to measure their knowledge gain after the intervention. The comparison of pre-test and post-test results helped to determine the effectiveness of each teaching method.

The logic behind this research design is to assess both the cognitive outcomes (knowledge gain) and affective outcomes (motivation and engagement) associated with traditional and flipped classroom teaching methods. By administering pre- and post-tests, the study aims to isolate the effects of the teaching methods on student learning. The use of a validated questionnaire ensures that the measures of motivation and engagement are reliable and accurate.

Table 2. Topics of STA113

Topic #	Topics	Weeks	Sessions	Hours
1	General concepts: Basic terminology and definitions	Week 1	0.5	1
2	Frequency distributions and graphs	Week 1	1.5	3
3	Data description	Week 2	1.5	3
4	Probability and counting rules	Week 3	2.5	5
5	Discrete probability distributions	Week 4	2.0	4
6	The normal distribution	Week 5	2.5	5
7	Correlation and regression	Week 6	1.5	3
Total		6	12	24

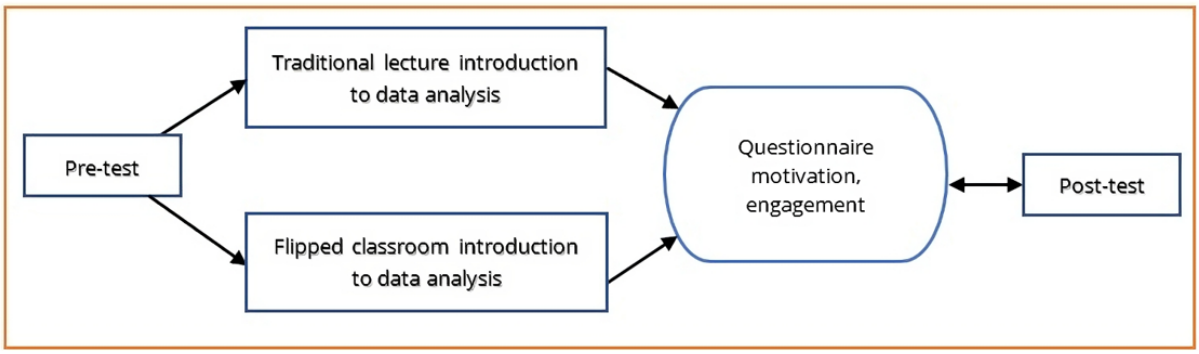

Figure 2. Experimental design of the study (Source: Authors)

Table 3. t-test of pre-test results: Empirical and control groups

Group	N	Mean	Standard deviation	t-value	Significance	Significance level
Control	35	11.53	1.65	0.215	0.830	Insignificant
Empirical	36	11.59	1.43			

Note. Statistically significant at $p < 0.05$

Traditional teaching methods were used to teach the topics of STA113 (**Table 2**) to undergraduates in the control group, whereas in the empirical group digital content, educational video, and Moodle learning management system were used to design e-content for the same topics, which was learned by the experimental group using flipped teaching approach. An achievement test was developed to measure cognitive achievement. The motivation and engagement of the participants were measured using a questionnaire. **Figure 2** illustrates the study's design.

Empirical and Control Group Equivalence

A pre-test of unit one was given to all the participants before applying the flipped classroom approach to detect the participant's equivalence. Afterward, the findings were compared using a t-test to ensure equivalence. As illustrated in **Table 3**, since p (0.830) is more than 0.05, the test is insignificant at 0.05. Accordingly, there is no significant difference between research groups (empirical and control).

Research Instrument (Achievement Test)

Researchers developed the achievement exam to investigate how flipped classroom teaching affects student achievement in STA113. A specification table was designed for this exam based on Bloom's cognitive domain taxonomy (see **Table 4**). It consisted of 20 multiple-choice questions in its final form. A correct response earned one mark, while a wrong response earned zero points. There was a maximum score of 20, and the test lasted 60 minutes.

Validity and Reliability of the Achievement Test

To detect the validity of the achievement test, it was illustrated, in its prototypical form, to university lecturers who specialize in curricula and teaching methods. The questions were revised in response to suggestions, and new ones were added as recommended, resulting in a valid test. Moreover, the reliability of it was verified by the test-retest method. Pearson's correlation coefficient was 0.881, which is sufficient.

Table 4. Post-test (achievement test) specification table

Topics	# of hours	Weight of topics	Bloom's taxonomy						Total
			Remember	Understand	Apply	Analyze	Evaluate	Create	
General concepts of STA113	1	4.2%	1	0	0	0	0	0	1
Frequency distributions and graphs	3	12.5%	0	0	1	0	1	1	3
Data description	3	12.5%	0	1	0	1	0	0	2
Probability and counting rules	5	20.8%	1	1	0	1	1	0	4
Discrete probability distributions	4	16.7%	1	1	1	0	0	0	3
The normal distribution	5	20.8%	0	1	1	0	1	1	4
Correlation and regression	3	12.5%	0	1	0	1	1	0	3
Total	24	100%	3	5	3	3	4	2	20

Table 5. The Likert scale options

Options	Ordinal	Extent of average
Very little	1st	1.00–1.80
Little	2nd	1.81–2.60
Moderate	3rd	2.61–3.40
High	4th	3.41–4.20
Very high	5th	4.21–5.00

Research Instrument (Questionnaire)

The research questionnaire used in this study was developed by the researchers, employing a Likert scale to assess how students' perceptions of flipped classrooms during STA113 lectures influenced their motivation and engagement. To ensure that the questions accurately measured learner motivation and engagement, several steps were undertaken.

First, the questionnaire was created based on an extensive review of the literature on motivation and engagement in educational contexts. The questions were carefully designed to align with established constructs, drawing on theoretical frameworks such as SDT and active learning principles.

To validate the content, the questionnaire was reviewed by a panel of experts, including professionals in educational psychology and psychometrics with specific expertise in student motivation and engagement. The experts provided feedback on the clarity, relevance, and appropriateness of the questions. Their suggestions were incorporated to refine the questionnaire, ensuring it effectively captured the intended constructs.

Additionally, a pilot test was conducted with a small group of students not involved in the main study. This pilot test helped identify potential issues, such as unclear wording or misinterpretation. Based on the feedback, further revisions were made to enhance the reliability and validity of the instrument. The Likert scale offered respondents the options of indicating their level of agreement as very high, high, moderate, little, or very little, as shown in **Table 5**.

The survey tool utilized in this study was separated into two sections. The 1st one collected demographic and other pertinent data from the undergraduates, while the second section focused on twenty specific items related to the study's objectives. To ensure quantitative data collection, a closed Likert scale was utilized. The researchers distributed the questionnaire to experts from various academic institutions to assess its reliability and validity. These specialists provided written feedback on the questionnaire's components, allowing the researchers to make the necessary adjustments to meet the study's goals. The reliability of the questionnaire was evaluated using Cronbach's alpha, resulting in a score of 0.835, which indicates good internal consistency.

Educational *Material*

Learning activities, educational video, and PPT presentations were developed and organized to teach STA113 using flipped learning. Additionally, relevant multimedia, assignments, and quizzes could be found in the Moodle learning management system. All undergraduates in the empirical group were able to log into the Moodle learning management system by using their accounts details. The same topics were given to a control group through conventional learning.

Table 6. The results of average and standard deviation of post-test

Group	N	Mean	Standard deviation
Empirical	36	16.32	1.21
Control	35	13.31	1.53

Table 7. The independent sample t-test of post-test

	Levene's test for equality of variances		t-test			
	F	Sig.	t	df	Sig.	Mean difference
Assumed equal variances	2.732	.080	10.356	105	0.000	3.01221
Non-assumed equal variances			10.343	94.080	0.000	94.08000

Table 8. Results of the statistical analysis of motivation

S/N	Statements	Mean	SD	Ordinal	Description
S8	I believe that the flipped classroom, with its suitable applications, enhances and encourages learners' self-learning skills.	4.78	0.760	1	Very high
S3	The flipped classroom encourages me to take responsibility for my own education.	4.75	0.770	2	Very high
S7	I think that the flipped classroom, with its applications, has improved teaching and learning.	4.61	1.022	3	Very high
S5	The lessons in the flipped classroom provide an interesting and motivating learning environment.	4.56	1.157	4	Very high
S4	I find learning the Introduction to data analysis course using the flipped classroom more exciting and motivating than traditional learning.	4.31	1.348	5	Very high
S1	I do not get bored when my instructor uses computers, the internet, and multimedia to explain lesson topics.	4.31	1.283	5	Very high
S10	The flipped classroom provides a more satisfying and relaxed classroom environment.	4.06	1.145	6	High
S9	I feel that using the flipped classroom at my university is more useful and motivating than the traditional lecture method.	4.00	0.793	7	High
S2	The flipped classroom is more motivating for me to learn than traditional methods.	3.78	0.797	8	High
S6	I prefer the flipped classroom because it allows me to learn at the time and place of my choosing.	3.64	1.099	9	High
Total		4.28	1.020		Very high

RESULTS

Study Results Related to Q1

The main focus of question 1 was to detect the effect of using the flipped class approach on learners' academic achievement in learning STA113 in higher education. To assess this, the mean scores in the formative assessment test were calculated and compared among the empirical group and the control group. A t-test for two independent samples was also used to specify the difference among the mean scores in the two groups (**Table 6** and **Table 7**).

According to **Table 6**, the test scores of the learners who were taught through the flipped method (mean [M] = 16.32, standard deviation [SD] = 1.21) were different from those who were taught traditionally (M = 13.31, SD = 1.53).

Based on the results in **Table 7**,the p-value (0.000) is less than 0.05, indicating that there are significant differences between both groups in terms of comprehending theSTA113 topics discussed in the lessons. This suggests that there is a substantial difference between both groups in understanding of the course content. Together with the research findings, suggests that the use of the flipped learning had a significant effect on learner's understanding of the target content.

The Results of Q2

The second question was to detect the influence of adopting the flipped class learning on the motivation of higher education students to learn STA113. To tackle the second question, the researchers computed the average scores and standard deviation. **Table 8** presents the participants' responses to statements (S1–S10) of the questionnaire associated to motivation.

Table 9. Results of the statistical analysis of engagement

S/N	Statements	Mean	SD	Ordinal	Description
S17	I prefer the flipped classroom activities because they pose questions that require a high level of thinking.	4.89	0.523	1	Very high
S12	The flipped classroom increases my contribution and participation in classroom discussions.	4.83	0.697	2	Very high
S19	The flipped classroom enhances my understanding of the subject I study.	4.78	0.681	3	Very high
S18	I gain more information on topics during the flipped classroom sessions than through traditional learning.	4.53	0.971	4	Very high
S11	The flipped classroom keeps me active and in a constant state of alert and focus during the session.	4.50	1.108	5	Very high
S15	The flipped classroom helps me develop my thinking skills.	4.44	1.182	6	Very high
S14	The flipped classroom helps me complete academic tasks more efficiently.	4.33	1.265	7	Very high
S16	The flipped classroom helps me become more self-knowledgeable.	4.03	1.108	8	High
S20	The flipped classroom has helped me concentrate better than in traditional lectures.	3.75	1.296	9	High
S13	The flipped classroom has made me more cooperative and engaged with other students during the lecture.	3.64	1.222	10	High
Total		4.37	1.010		Very high

These results shown in **Table 8** suggest using flipped classes as a teaching approach positively impacts learner's motive to study STA113 in higher education (M = 4.28, SD = 1.02). Specifically, students in the empirical group reported higher levels of motivation and a sense of responsibility for their own learning in comparison to the control group. The high level of consensus on S8 further supports the notion that flipped classroom can enhance and encourage self-learning skills among learners.

The results indicate that S3 "The flipped classroom encourages me to take responsibility for my own education." received the second highest degree of agreement among participants, with a mean score of 4.75, and a high level of consensus. In addition, S7, " I think that the flipped classroom, with its applications, has improved teaching and learning." received the third-highest degree of agreement among participants, with a mean score of 4.61 and a high level of consensus. Additionally, statements S5, S4, and S1 also received a "really high" ranking. The responses to S10, " The flipped classroom provides a more satisfying and relaxed classroom environment." suggest that it a "high" degree of agreement, with an average score of 4.06. Similarly, S9, S2, and S6 received a "high" level of agreement, with respective mean values of 4.00, 3.78, and 3.64.

The Results of Q3

The third question was to detect the effect of implementing the flipped class method on the engagement of higher education undergraduates to learn STA113. To address this question, the researchers calculated the average scores and standard deviations, and **Table 9** presents the participants' responses to statements (S11-S20) of the questionnaire associated to engagement.

The findings presented in **Table 9** state that the average score for all statements related to engagement (S11-S20) was 4.37, with a standard deviation of 1.01. The findings suggest that using the flipped classroom method led to a very high level of engagement among learners in the empirical group for STA113. It is noteworthy that S17, " I prefer the flipped classroom activities because they pose questions that require a high level of thinking." had the highest average score of consensuses (4.89) among the participants, with a very high level of agreement. Moreover, the responses to S12, "The flipped classroom increases my contribution and participation in classroom discussions." received the second-highest degree of agreement with an average score of 4.83 and a strong rating. Similarly, S19, "The flipped classroom enhances my understanding of the subject I study." was ranked third highest in terms of unanimity, with an average score of 4.78, indicating a maximum level of agreement. Additionally, S18, S11, S15, and S14 received a "strong" rating, with respective average values of 4.53, 4.50, 4.44, and 4.33. The lowest average score of 3.64 was obtained for S20, "The flipped classroom has helped me concentrate better than in traditional lectures." which still indicates a high level of agreement. Furthermore, S16, "The flipped classroom helps me become more self-knowledgeable." and S20, "The flipped classroom has helped me concentrate better than in traditional lectures." also received a high degree of agreement.

Table 10. Means and standard deviations of the student answers according to gender

Gender	N	Mean	Standard deviation	t-value	Significance	Significance level
Male	16	4.36	.279	1.611	0.403	Not significant
Female	20	4.20	.320			

Table 11. One-way ANOVA test for student academic performance (CGPA)

		Sum of squares	df	Mean square	F	Sig. (tailed)	Sig. level
Student academic performance (CGPA)	Between groups	.880	4	.220	2.746	0.046	Significant
	Within groups	2.483	31	.080			
	Total	3.362	35				

Study Results Related to Q4

The study examined if there were significant differences in student motivation levels based on several variables, including gender, academic performance (CGPA), and academic level. The researchers calculated average scores and standard deviations for relevant questionnaire statements pertaining to each variable. A t-tests, one-way ANOVA, and LSD tests were also employed to specify the significance of average differences. Based on the results, the researchers have outlined the findings related to each research variable and its impact on student motivation levels, as follows:

Gender variable

The study adopted a T-test to analyze the significance of differences in motivation levels between male and female students, as illustrated in **Table 10**. The findings revealed that the observed p-value (0.403) was greater than the significance level of 0.05. Therefore, the test was insignificant at the 0.05 level, suggesting that there was no significant difference in motivation levels for the flipped method based on gender among the participants in the study.

Academic performance variable (CGPA)

Table 11 displays the ANOVA test results for students' responses to a particular variable. The results reveal statistically significant differences in learner's motive according to their academic performance (CGPA), with a p-value of 0.046, that is below the intended level of statistical significance (0.05).

To further examine the source of these differences, the LSD test was employed, and the findings are presented in **Table 12**. Upon analyzing the multiple comparisons in **Table 12**, it is evident that the significant differences in students' academic performance (CGPA) can be attributed to variations between students with excellent CGPA (3.6-4.0) and those with low CGPA (below 2.0), with a mean difference of .433 ($p = 0.038$). Additionally, there were significant differences between students with very good CGPA (3.0-3.5) and those with pass CGPA (2.0-2.4), with a mean difference of .375 ($p = 0.018$). The mean difference between students with pass CGPA (2.0-2.4) and those with low CGPA (below 2.0) was .566 ($p = 0.010$).

Academic levels variable

Table 13 exhibits the findings of the ANOVA test conducted on the learner's responses regarding their academic levels. **Table 13** reveals that there are no significant differences in participants' motivation based on academic levels, with a p-value of 0.076, that is higher than the intended level of statistical significance (0.05).

Study Results Related to Q5

A statistical analysis was made to specify whether there are significant differences in students' engagement with the flipped classroom based on their gender, academic performance (CGPA), and academic levels. The researchers computed the average scores and standard deviations for the relevant questionnaire statements related to the variables of interest. To evaluate the significance of the average differences, t-test, one-way ANOVA tests, and LSD experiments were made. Based on the research variables, the following findings were observed:

Table 12. LSD test results for the variable undergraduate's academic performance (CGPA)

(I) Students' CGPA	(J) Students' CGPA	Mean difference (I-J)	Standard error	Significance	95% confidence interval	
					Lower bound	Upper bound
Below 2.0	2.0-2.4	.56667*	.20666	.010	.1452	.9882
	2.5-2.99	.26667	.18628	.162	-.1133	.6466
	3.0-3.5	.19167	.18267	.302	-.1809	.5642
	3.6-4.0	.43333*	.20010	.038	.0252	.8414
2.0–2.4	Below 2.0	-.56667*	.20666	.010	-.9882	-.1452
	2.5-2.99	-.30000	.15500	.062	-.6161	.0161
	3.0-3.5	-.37500*	.15063	.018	-.6822	-.0678
	3.6-4.0	-.13333	.17136	.442	-.4828	.2161
2.5–2.99	Below 2.0	-.26667	.18628	.162	-.6466	.1133
	2.0-2.4	.30000	.15500	.062	-.0161	.6161
	3.0-3.5	-.07500	.12117	.540	-.3221	.1721
	3.6-4.0	.16667	.14613	.263	-.1314	.4647
3.0–3.5	Below 2.0	-.19167	.18267	.302	-.5642	.1809
	2.0-2.4	.37500*	.15063	.018	.0678	.6822
	2.5-2.99	.07500	.12117	.540	-.1721	.3221
	3.6-4.0	.24167	.14149	.098	-.0469	.5302
3.6–4.0	Below 2.0	-.43333*	.20010	.038	-.8414	-.0252
	2.0-2.4	.13333	.17136	.442	-.2161	.4828
	2.5-2.99	-.16667	.14613	.263	-.4647	.1314
	3.0-3.5	-.24167	.14149	.098	-.5302	.0469

* The mean difference is significant at the 0.05 level

Table 13. ANOVA test for variable academic levels

		Sum of squares	df	Mean square	F	Sig. (tailed)	Sig. level
Academic levels	Between groups	.642	2	.214	2.518	0.076	Not significant
	Within groups	2.720	33	.085			
	Total	3.362	35				

Table 14. Means and standard deviations of the undergraduate's answers according to the gender variable

Gender	N	Mean	Standard deviation	t-value	Sig. (tailed)	Significance level
Male	16	4.40	.354	.453	0.694	Not significant
Female	20	4.35	.308			

Table 15. Results of ANOVA test for student academic performance variable (GPA)

		Sum of squares	df	Mean square	F	Sig. (tailed)	Sig. level
Student academic performance (CGPA)	Between groups	.375	4	0.094	0.871	0.492	Not significant
	Within groups	3.337	31	0.108			
	Total	3.712	35				

Gender

The t-test analysis illustrated that there were no significant differences in engagement levels among male and female learners in the context of the flipped class, as shown in **Table 14**. The results indicated that the observed p-value (0.694) was greater than the significance level of 0.05. Consequently, the test was insignificant at the 0.05 level, suggesting that there was no significant difference in engagement levels with the flipped class according to gender among the participants in the study.

The variable of academic performance (GPA)

Table 15 presents the results of the one-way ANOVA test conducted to examine the impact of student academic performance (GPA) on engagement levels with the flipped classroom approach. The results indicated no statistically significant differences in engagement levels about learners' academic performance since p-value = 0.492, which is higher than the level of significance of 0.05. Therefore, it is interpreted that students' academic performance did not significantly influence their engagement with the flipped class method within the context of the research.

Table 16. ANOVA test for academic levels variable

		Sum of squares	df	Mean square	F	Sig. (tailed)	Sig. level
Computer skills	Between groups	.210	3	.070	0.640	0.595	Not significant
	Within groups	3.502	32	.109			
	Total	3.712	35				

Academic levels variable

Table 16 results of the ANOVA test done to detect the effect of academic levels on engagement with the flipped classroom approach. From the results, no statistically significant differences in the level of engagements based on academic levels were detected since the p-value was 0.595 above the 0.05 significance level. Results, therefore, indicated that the learner's level of engagement with the flipped class was not much influenced by the academic levels within the context of this research.

DISCUSSION

The results of the research prove that the use of flipped classes in the STA113 course positively affected the undergraduate's academic performance in the empirical group, compared with their match in the control group. Specifically, the mean score of 16.32 for the students in the empirical group is more than the 13.31 mean score of students in the control group. In addition, the statistical analysis of the collected data ended up with a p-value = 0.000, which is less than the significance level of 0.05; this means there are significant differences between the two groups. As a result, flipped classrooms had a substantial effect on learning the course content. Accordingly, this finding is in line with previous studies carried out by Lopes and Soares (2018), Awidi and Paynter (2019), Kazanidis et al. (2019), and Busebaia and John (2020).

The second question, which probed the effect of the flipped class on the learner's motivation to study STA113 at higher education, found that using the flipped classroom gave out very high results in motivating the empirical group, as shown in **Table 8**. The mean for all questionnaire statements (S1-S10) related to motivation stood at 4.28 with a 1.02 standard deviation. This result supports previous studies showing the positive effects of the flipped class on study motivation (Awidi & Paynter, 2019; Rothman, 2022).

The findings associated with the effect of the implementation of the flipped classroom for learning STA113 on learners' engagement in higher education showed that the participants of the empirical group were more highly active and active as compared to their counterparts in the control group, as viewed in **Table 9**. The respondents in the empirical group depicted higher behavioral and emotional engagement. In the flipped classroom approach, students had already reviewed the content of the term in advance at home. Therefore, they could participate in relevant activities of the class: asking questions or solving a problem together with peers. Another advantage is that the mentor could move around the classroom, providing individual assistance on a one-on-one basis, which certainly cannot be carried out in the traditional lecturing approach. This finding agrees with several research studies like Elmaadaway's (2018) and Loveys and Riggs (2019).

It is worth noting that the findings also revealed a significant difference in students' motivation levels based on their academic performance (CGPA), as illustrated in **Table 11**. The LSD test findings in **Table 12** revealed that students with excellent CGPA (3.6-4.0) and very good CGPA (3.0-3.5) had significantly higher motivation levels compared to those with lower CGPA (below 2.0). Furthermore, students with pass CGPA (2.0-2.4) had significantly higher motivation levels compared to those with lower CGPA (below 2.0). However, there are no positive differences in levels of motivation depending on the variable of academic levels (**Table 13**) or gender (**Table 10**).

Likewise, the 5th question of the research investigated whether there were any differences in learner's engagement with flipped classroom based on their gender, student academic performance (CGPA), and academic levels. The results are presented in **Table 14**, **Table 15**, and **Table 16**, and indicated that there were no significant differences according to these variables.

Nonetheless, the findings of this research disagree with the those of previous research studies (Bredow et al., 2021; O'Flaherty & Phillips, 2015; Strelan et al., 2020; Van Alten, et al., 2019), which reported that flipped classroom had a slight or moderate impact compared to the traditional teaching approach.

CONCLUSION

The objective of this study was to measure the influence of using the flipped classroom as a teaching method on the students' academic achievement, engagement, and motivation for learning introduction to data analysis course (STA113). It is concluded that the method of flipped classroom could be a successful and effective way to teach and learn introductory courses in higher education institutions, especially in the field of data analysis. It has the potential to improve learner's motive, engagement, and academic performance. Furthermore, our research has revealed that the level of motivation and engagement of students towards the flipped classroom approach is influenced by their academic performance, as measured by their CGPA. Nevertheless, no significant difference was found concerning gender or academic level. Educators can implement that kind of classroom model in their courses to simplify students' learning processes and to provide them with an interactive and engaging learning experience. Our results provide further evidence that the flipped classroom positively impacts student learning. However, further research is required to detect lasting effects of using such classroom method in higher education and to determine the extent to which using such kind of classroom specifically contributes to increased motivation among students because we realize that the high level of motivation observed in the empirical group could be attributed to various factors other than using the flipped classroom approach, such as the novelty of the teaching method, the instructor's enthusiasm, or the course content quality.

Limitations

This study has several limitations that should be acknowledged when interpreting the findings. Firstly, the use of a quasi-experimental design without random assignment of participants to the control and experimental groups introduces the potential for selection bias, which may limit the generalizability of the results. Additionally, the relatively small sample size of 71 students restricts the statistical power of the study and may reduce the applicability of the findings to broader educational contexts. The short duration of the study, conducted over a six-week summer semester, also limits the ability to capture long-term effects of the FCM on student motivation, engagement, and academic performance. Moreover, the reliance on self-reported data to measure motivation and engagement could introduce biases related to social desirability or inaccuracies in self-assessment. Furthermore, the study's focus on a single course, STA113, means the results may not be applicable to other courses or disciplines.

Recommendations

Given the above limitations, it is recommended that future research on the FCM be conducted with larger and more diverse samples to enhance the generalizability of the findings. Longitudinal studies would be beneficial to examine the long-term impacts of the FCM across multiple academic periods. Whenever possible, randomized controlled trials should be employed to minimize selection bias and increase the validity of the results. Additionally, incorporating objective measures, such as behavioral data or performance analytics, could provide a more comprehensive understanding of the effects of the FCM. Further exploration of the model's application in different disciplines and educational levels is also recommended to assess its broader effectiveness. Lastly, investigating the role of various technological tools and platforms used in the FCM could offer deeper insights into how these elements contribute to student outcomes.

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