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THE EFFECT OF FLIPPED CLASSROOM INSTRUCTION ON PRIMARY STUDENTS' SCIENCE ACHIEVEMENT: AN EXPERIMENTAL STUDY

Sher Alam Khan
PhD Scholar in Learning Science and Digital Technologies, University of Modena Reggio Emilia, Italy.
Corresponding author email: sher.khan@unimore.it
Giorgio Poletti
Associate professor, Department of Humanistic, University of Ferrara, Italy.
Mazhar Alam
MPhil Scholar, Center for Education & Staff Training, University of Swat.
Farooq Nawaz Khan
Professor, Center for Education & Staff Training, University of Swat.
Sajjad Hussain
Professor, Center for Education & Staff Training, University of Swat.

Abstract.
In this rapid technological growth, the flipped classroom is gaining more attention and acceptance in education. The primary purpose of this study was to investigate the effects of flipped classroom instruction on science achievements in primary education. This was an experimental study; a sample of 60 5th-grade students participated. The average age of the students was between 12 and 13 years. A pre- and post-test was administered to obtain the results. Data collection took place for five working weeks (April and May). The results indicate that flipped classroom instruction significantly enhances primary students' performance in science compared to traditional teaching approaches. Students in the experimental group, who engaged with pre-class video content and participated in active problem-solving activities during class, showed greater achievement levels than those in the control group.
Keywords: *Flipped Classroom, Traditional Teaching Method, Primary Students, Science Achievements, Technology Integration.*

1. Introduction

Over the past 10 years, especially after COVID-19, information and communication technology (ICT) has rapidly spread throughout all fields of education and is currently a primary priority for all educational institutions. Integrating information communication technology (ICT) into teaching and learning is challenging for teachers and students at all academic levels. Under the influence of ICT, new learning models are developing to improve education quality and learning outcomes (Županec, Miljanović, & Pribićević, 2013). The expanding popularity of ICT, the amount of time youngsters spends in front of computers, laptops, and tablets, and the ease with which students absorb technological advancements all require significant technology integration across the primary school curriculum (Costa et al, 2013). Children skilled in ICT in primary school contribute more complete intellectual activity to their learning by doing more independent material research, fundamental understanding, and active, creative applications.

The primary purpose of science education is to assist individuals in acquiring a specific degree of scientific knowledge that will support formal education in schools (Wang & Schmidt, 2001). Reforms have raised concerns regarding the science educational model's ability to equip students with 21st-century skills for success in their future careers. The scientific community has made several attempts to address the issues that students face, such as disengagement and negative attitudes toward science education (Howard, 2017). However, the way to give this training form

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has been insufficient to meet the time needs (Cagande & Jugar, 2018). Thornburg (2009) identified five key difficulties that science students confront that instructors must overcome to achieve social expectations: 1) a lack of trained instructors; 2) studying science as a dynamic human activity rather than a topic; 3) a lack of practical scientific learning; 4) learning science as an inquiry and process; and 5) integrating science into other subjects. There is rising concern about the quality of scientific education, necessitating a shift away from traditional didactic teaching methods (Weiman, 2008a) to prepare students for future job opportunities. Other research, such as Jeong et al. (2019), found that standard scientific teaching approaches are poor at training children.

A flipped classroom is a teaching technique and a type of blended learning that aims to increase student engagement and learning by having students complete readings at home and work on real problem-solving during class time. It also provides a more adaptive and engaging learning environment (Wang et al. 2022; Ustun & Tracey, 2021). In contrast, blended learning combines both online and offline teaching modalities. The flipped classroom is a technologically based instructional strategy. This is related to blended learning (Westermann, 2014). Blended learning immediately advances SDG4 by giving educational opportunities in remote regions and under harsh conditions such as COVID-19 (Ramalingam et al., 2022; Wang & Teter, 2018).

The results of various studies show that flipped classroom interventions are effective for various disciplines (Davies et al., 2013; Fautch, 2015; Hung, 2015; Mason, Shuman, & Cook, 2013; Missildine, Fountain, Summers, & Gosselin, 2013; Schultz, Duffield, Rasmuseen, & Wageman, 2014; Strayer, 2012; Wilson, 2013). Flipped classrooms are relatively very famous (Tang et al., 2020). Most studies revealed an encouraging result. Flipped classrooms are more effective than conventional classrooms (Davies, 2013), and a flipped classroom is the conversion of a teacher-centered approach to a student-centered learning approach (Kong, 2014).

The flipped classroom is the actual technique to promote student academic performance (Bernard & Ghaffari, 2019; Castedo et al., 2019; Chen & Law, 2016; Sung et al., 2017) more than the traditional classroom for both active and inactive learners (Wang et al., 2022). In their quasi-experimental research, Missildine et al. (2013) found that three approaches were compared: traditional lecture only, lecture and lecture capture backup, and the flipped classroom approach of lecture capture with innovative classroom activities. They determined that students learn more in a flipped classroom than through other learning methods. Students achieve 10% more in flipped classrooms than traditional ones (Bidwell, 2014; Yilmaz & Keser, 2017). Wang et al. (2022) discovered that the flipped classroom is more productive than the traditional classroom, for both active and passive students. Recently, the flipped classroom method has received much attention in the field of education all over the world (Al Mamun et al., 2022; Korkmaz & Mirici, 2021; Latorre-Cosculluela et al., 2021; Nerantzi, 2020).

Learners of the 21st century are facing numerous challenges in the traditional classroom (Sarker et al. 2023). Similarly, Thornburg (2009) highlighted five main challenges faced by science students that require addressing by educators to meet societal expectations: lack of qualified teachers, learning science not only as a subject but as a dynamic human activity, lack of hands-on science learning, learning science as an inquiry and actual process, and relating science to other subjects. Other studies, such as Jeong et al. (2019), revealed that traditional teaching methods in science are not effective in instructing students, and this increasing concern about the science education quality necessitates a shift from the traditional didactic teaching approach (Weiman, 2008a) for the preparation of students' future career development. To successfully incorporate technology into the curriculum, it is necessary to investigate teachers' pedagogical beliefs and attitudes (Ertmer et al. 2010). For example, recent research has evaluated technology

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integration's early beliefs and problems using the flipped class technique. According to Ajzen's (1991) historical study, teachers' views impact students' attitudes or feelings about engaging in particular activities. Efficacy, comfort, frequency of use, and attitude toward technology are four relevant areas that permit additional research about the beliefs that surround the flipped classroom method based on technological trends (Mayo, Kajs, & Tanguma, 2005; Tanguma, Underwood, & Mayo, 2004; Willis, 2006).

Theoretical Background

Two professors, Jonathan Bergmann and Aaron Sams (2012), used the flipped classroom teaching approach to teach their chemistry students a unique teaching style. Today, it is an increasingly widespread learning and teaching style in schools worldwide. Bergman and Sams discovered that by flipping the chemistry teaching model so that students watched video lectures at home and completed homework in class under their supervision, students' grades improved, and they had more time for various types of activities that helped them grasp the subject matter more thoroughly than ever before (Bergmann & Sams, 2009). The FC model's developers have encouraged many teachers to utilize this teaching technique in their fields of specialization, including science, technology, engineering, and mathematics, by promoting it in educational institutions worldwide (Eichler & Peeples, 2016). As a result, this approach is often employed in American schools (Warter-Perez & Dong, 2012).

Around the world, schools and colleges are quickly adopting the flipped classroom model, which is also drawing more and more attention. Most concentrate on applying the FC in educational contexts and comparing the results to the conventional lecture method (Hultén & Larsson, 2016). For instance, Morton and Colbert-Getz (2017) discovered that the FC might improve students' performance in higher-order learning outcomes more effectively than in the lecture classroom. According to these writers, the FC technique could be the most advantageous in helping students analyze the course materials.

Some studies have assessed the success of instructional tactics in motivating students to study specific subjects while accounting for student participation in diverse educational environments. Motivational influences impact students' decisions to study and finish activities, as well as the mental effort necessary to understand the material. If a student is uninterested in the task or the subject, they will not put forth the cognitive effort to comprehend the educational content, resulting in low performance. Higher levels of student engagement in a particular educational setting will likely result in increased cognitive effort, leading to improved performance (Paas et al., 2005).

Research Questions

1. What is the effect of the flipped learning approach on science students, promoting positive learning emotions?
2. Is there any significant difference in science students' engagement in a flipped classroom compared to the traditional approach?
3. Does a flipped classroom enhance students' engagement and motivation in the subject of science?

2. Research Methodology

The study intends to investigate how the flipped approach enhances students' engagement and motivation in the subject of science at the primary level. The study lasted five weeks at the government primary school Shangla, KPK, Pakistan. In this experiment, 75 students (56 male and 19 female) of the 5th grade participated. All those students come from different family backgrounds and are between 12 and 13 years old. The study was truly experimental, examining the flipped approach's impact on the science subject. Its design includes control (C) and

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experimental (E) groups. The study was conducted by the principal author and two volunteer science teachers from the sample school.

Permission was obtained from the District Education Officer of District Shangla and the students' parents. The researcher explains the objectives of the study and course contents in detail to students and teachers. A pretest was developed to measure students' ability in the selected topics. The pretest was designed according to the 5th-grade general science textbooks of Khyber Pakhtunkhwa. The test consisted of 15 questions: 5 MCQs from animal classification and characteristics of animals, 5 MCQs from plant classification and characteristics of plants, and 5 MCQs from space and satellite (see Table 1). The science experts and concerned science teachers from different schools validated the pretest. Both the control and experimental groups were instructed separately. The flipped approach was taught to the experimental group, whereas the control group used traditional methods. The study population consisted of students in the 5th grade in the government school of district Shangla, Pakistan. There were 75 students enrolled, but out of those, 60 students participated. The remaining 15 did not participate in this study for some reason; some were on medical leave, and some were on extended vacation. Anyhow, there were 30 participants in the experimental group, and 30 participants were in the control group. Pre-tests were administered, and after the pre-test evaluation, groups (control and experimental) were formed based on their performance. The experimental group was treated with the flipped approach (laptops, smartphones, and tablets), and the control group was taught in the traditional method. A total of 05 weeks of science was delivered to students using a flipped approach.

Table 1. The contents taught to the students of the experimental and control groups.

Main Topic	Subtopics
Classification of Organization	● Classification and characteristics of animals ➢ Classification of vertebrates ➢ Classification of Invertebrates ● Classification and characteristics of flowering plants ➢ Monocot ➢ Dicot
Space and Satellite	● The moon of the other planets ➢ Artificial satellites ➢ Importance of artificial satellite ➢ Uses of various satellites

3. Results

Table 2: The descriptive statistics of the pretest and the corresponding t value.

Group/Test	***N***	***M***	***SD***	***Df***	***t***	***Sig.***
Pre-test Control Group	30	7.0333	2.05918	29	18.708	.000
Pre-test Experimental Group	30	7.5333	2.20866	29	23.642	.000

As presented in Table No. 2, there was no statistically considerable variance in the mean score of the students in the two groups determined on the pretest. Based on the performances accomplished on the pre-test, the experimental (E) and control (C) groups were equalized according to the students' knowledge of the classification and characteristics of animals and plants, monocots and dicots, and the moon of the other planet.

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Table 3: The descriptive statistics of the pre-test vs. post-test between the experimental group.

Group/Test	***N***	***M***	***SD***	***Df***	***t***	***Sig***
Pre-test Experimental Group	30	5.1000	1.51658	29	18.419	.000
Post-test Experimental Group	30	9.5333	2.20866	29	23.642	.000

Table 3 shows the statistics between pre- and post-experimental groups. As clearly shown in the table, the mean score was 5.1000, and the standard deviation was 1.51658 at the pre-test of the experimental group before treatment. After the treatment, the statistics indicate that the flipped classroom enhanced the students' science achievement, and the mean score and standard deviation changed to 9.5333 and 2.20866, respectively, showing a significant difference between the pre- and post-test of the experimental group.

Table 4 shows the descriptive statistics of the pre-test vs. post-test between the control group.

Group/Test	***N***	***M***	***SD***	***Df***	***t***	***Sig***
Pre-test Control Group	30	4.7667	1.88795	29	13.829	.000
Post-test Control Group	30	7.0333	2.05918	29	18.708	.000

Table 4 shows the descriptive statistics of the control group's pre- and post-test. The mean score was 4.7667, and the standard deviation was 1.88795 in the sample group's pre-test. However, in the post-test, the mean score and the standard deviation changed slightly because the class size was reduced to 30 students. This statistic shows that a flipped classroom is an effective teaching strategy in an overcrowded classroom.

4. Discussion

In this research study, we compared the science achievements of primary school students in a flipped classroom with those in a traditional one. The findings of this study indicate that flipped classroom instruction has a significant positive effect on primary students' science achievement compared to traditional teaching methods. Students in the experimental group, who were exposed to pre-class video materials and engaged in active, problem-solving tasks during class time, demonstrated higher achievement levels than those in the control group. This suggests that the flipped model, by shifting direct instruction to homework and emphasizing interaction and engagement during class, enhances students' understanding and retention of scientific concepts. Moreover, the format may encourage greater student autonomy and preparation, leading to deeper cognitive processing of the subject matter. Analysis revealed that those students who participated in a flipped classroom significantly enhanced their science achievements compared to those who participated in traditional ones. These results are similar to findings reported from other research, for example, a study by Županec et al. (2018), which indicates that the flipped classroom method helps decrease students' mental strain while enhancing their performance. The assessment of effectiveness and student engagement in the teaching methods determined that the flipped classroom approach is a viable and effective strategy for teaching biology (science) at the primary level. Similarly, other studies demonstrate a positive correlation between efficacy or confidence in technology and technology use, such as in the flipped classroom (Chen, 2010; Palak & Walls, 2009).

The second outcome revealed that students who engaged with science content through the flipped classroom (FC) method performed better on the post-test than those taught using traditional methods. Similar findings demonstrate that the flipped classroom (FC) is an actual technique to

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promote student academic performance (Bernard & Ghaffari, 2019; Castedo et al., 2019; Chen & Law, 2016; Sung et al., 2017) more than the traditional classroom, for both active and inactive learners (Wang et al., 2022). The flipped classroom method has received much attention in education, especially science, to equip students with 21st-century skills worldwide. It was also anticipated that successfully integrating pre-class and in-class activities in the flipped classroom (FC) model could enhance test results (Al Mamun et al., 2022; Korkmaz & Mirici, 2021; Latorre-Cosculluela et al., 2021; Nerantzi, 2020). Student performance was assessed through a multiple-choice test, and the results indicated that the flipped classroom group achieved significantly higher scores than the traditional classroom (TC) group. Thus, students grasp science concepts more effectively and with greater comprehension when preparing for class and engaging in interactive learning. These results directly align with other research studies, for example, Alvarez, 2012, in Math, Science, and Social Studies; Cheng et al., 2017, in Histology; Day & Foley, 2006, in computer interaction courses; and Tune et al., 2013, in Cardiovascular, Respiratory, and Renal Physiology, demonstrating that implementing the FC approach across various secondary and higher education disciplines considerably enhances academic performance and students' grades.

The results showed that a flipped classroom was a more effective teaching method than a traditional one. These findings were reliable within the research findings of Davies et al. 2013; Fautch, 2015; Hung, 2015; Mason, Shuman, & Cook, 2013; Missildine, Fountain, Summers, & Gosselin, 2013; Schultz, Duffield, Rasmussen, & Wageman, 2014; Strayer, 2012; Wilson, 2013; & Wang et al., 2022. Additionally, student achievements and satisfaction improved in flipped classrooms compared to traditional classrooms. These findings were similar to many studies. Such as Davies et al., 2013; Hung, 2015; Kong, 2014; & Mason et al., 2013. Thus, a flipped classroom could be a suitable and motivating teaching method for students because of the diversity of flipped classrooms, providing immediate feedback, use of modern teaching methods (including group work, discussion, and presentation), use of modern equipment, and internet-based Web 2.0 tools.

5. Conclusion

This research supports implementing flipped classroom methods as an effective teaching strategy in elementary science education. The findings emphasize the model's ability to enhance student achievement by encouraging active learning settings and focusing on student-centered instruction. In light of these advantages, teachers and curriculum designers should consider incorporating flipped classroom techniques into science education at the primary level. Future studies might investigate the enduring impacts of this approach and its relevance across various subjects and educational settings. This research is significant because it provides experimental evidence that using a flipped classroom (FC) in science teaching in primary school contributes to more efficiency and student involvement than the traditional approach. Students who learned the science content using the flipped classroom (FC) approach achieved greater achievement than those who used the traditional approach. Additionally, this approach accommodates various learning preferences, allowing students to interact with instructional materials at their own speed before class. However, effective implementation necessitates thorough planning, which includes ensuring access to digital resources, providing teacher training, and establishing student support systems to guarantee fair learning opportunities. Future studies could investigate the lasting effects of this model, its influence on diverse student groups, and how it relates to factors such as age, subject area, and technological infrastructure. In summary, the flipped classroom is an encouraging advancement in primary education that deserves wider adoption and more in-depth exploration.

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6. Ethical Consideration

Formal consent was obtained from all participants involved, and several meetings were conducted with key stakeholders, including the school head, teachers, guardians, parents, and the Parents-Teacher Committee (PTC). Since the study involves young learners, obtaining informed consent from students and parents or guardians is necessary. To facilitate this process, we involved the Parents-Teacher Committee (PTC). The parents and their children (5th-grade students) attended the meeting. The researcher discussed the research aims and objectives in detail and explained to everyone in the meeting the purpose of the study, the procedures involved, any potential risks, and the expected benefits of the study. It was emphasized that participation is entirely voluntary, and the parents have the right to withdraw their child from the study without any negative consequences.

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