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Relationship Between Teaching Styles and Mathematics Achievement of Ibadan North Secondary School Students: Practical Application of Peer-Cooperative Learning to Improve Retention of STEM Majors

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Abstract: Teachers and teaching styles are two important factors influencing students' academic performance. In this action research study, we investigated the differential effectiveness of two teaching methods, conventional learning (CL) and peer-cooperative learning (PCL), on students' academic performance in fractions. A sample of 120 tenth grade mathematics students from Ibadan North Local Government Area of Oyo State in Nigeria was used for the study. The students were selected from three different secondary schools and grouped into two groups: the experimental (PCL) group and the control (CL) group, each having 60 students. A sample of 5 multiple-choice objective and 5 theory test questions titled Fraction Performance Test (FPT) was used to measure their academic performance after the treatment, and the assessment test scores were recorded. Descriptive statistics of the mean were used to answer the research question, while the two-way ANOVA technique was adopted for testing the research hypothesis at an alpha of 0.05. Summarily, the F (3, 116) statistic (= 8.55, $p < .001$) indicates significant differences in the effectiveness of the teaching methods. The mean scores also reveal that peer-cooperative learning was more effective than the conventional teaching approach. While the former proved to be a more efficacious treatment for female students, the latter was more suitable for male students. We recommend that different approaches be attempted by teachers, and the most effective in overcoming students' resistance to learning and improving their academic performance be adopted.

Keywords: *Conventional learning, cooperative learning, instructional strategies, peer tutoring, STEM.*

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Introduction

The performance of students in STEM majors in Nigeria has remained average or below average, and this is not a good trend considering the importance of education to national development. The pass rate of students that sat for Physics, Chemistry, and Biology in the West Africa Senior School Certificate Examination (WASSCE) in Nigeria between 2000 and 2009 did not surpass 50%, except for Physics in 2004 and 2006 and Chemistry in 2003 (Ogunleye, 2011). Similarly, a critical analysis of students' academic performance in the WASSCE from 2008 to 2012 in another study revealed an average academic performance with a mean success rate of 37.27%, 46.3%, 47.44%, and 56.01% in biology, chemistry, mathematics, and physics, respectively (Sakiyo & Badau, 2015). This shows that the performance has not really improved within the thirteen years considered. Several factors are responsible for this poor performance, and the influence of teachers and teaching methods has also been highlighted as contributory factors. One of the subjects that specifically lacks competence and quality in teaching is mathematics, as reflected in the results presented.

Professor E. G. Begle said, "We have learned a lot about teaching better mathematics but not much about teaching mathematics better" (Crosswhite, 1987, p. 54). In the past, there has been far too much mechanical teaching (traditional or conventional approach) that has not focused on learners' diverse needs, and the children have not always been encouraged to discover the rules for themselves. To meet the students' learning needs, a blend of a variety of methods

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may be required. Highly situated and integrated instruction positively influences students' perceptions of their affective mathematics engagement (Lee et al., 2019). The teacher's responsibility is to identify which instructional strategy will best address the students' mathematical learning needs and when to apply it. Teachers therefore need to be flexible and dynamic in their styles of teaching.

Teaching styles are a multidimensional construct that is based on the way teachers act in the classroom (Grasha, 1996). They are a set of teaching tactics employed by the teacher to help students acquire knowledge or skills (McCoy, 2006). Basically, teaching styles in mathematics generally fall into two categories: teacher-centred and student-centred. Other methods such as problem-solving methods, lecture methods, questioning methods, discovery methods, content-focused methods, interactive/participative methods, cooperative learning, project-based learning, inquiry-based learning, etc. fall under the two main categories mentioned above. Canto-Herrera and Salazar-Carballo (2010) summarised that teaching styles can be examined based on teachers' behavior (Lowman, 1990), by associating people with unique teaching methods (Bonwell & Eison, 1991), and on conceptual bases forming teaching philosophy (Grasha, 1996). Most importantly, teachers should design instructional methods that take care of students' diverse learning styles and remain sensitive to them during the instruction process (Anyamene & Odalonu, 2022).

One approach that has been regarded as highly effective to address the diverse individual needs of students is one-on-one instruction (Downing et al., 2003). However, this is cumbersome since the common practice in most public schools is to have 15 to 40 students per teacher (Harris & Sherman, 1973) or more. The stress involved in having to engage every member of the class in one-on-one tutoring, the complex nature of our curriculum, and the limited time frame allotted to teachers to take classes make it unrealistic. A better approach is to find a way to actively engage the students in groups in the teaching-learning process.

Based on the idea of associating people with a particular teaching method, Bonwell and Eison (1991) classified teaching styles using the level of active learning and the level of risk. Active learning are activities that students get involved in to construct knowledge and understanding, like participating in class discussion or peer tutoring (Brame, 2016; Carr et al., 2015; Freeman et al., 2014). Instructors have applied this highly productive pedagogical approach for Science, Technology, Engineering, and Mathematics (STEM) education (Zhu, 2020) and rated it above traditional style (Freeman et al., 2014; Lund & Stains, 2015). The assumption by some educators that teachers' complete and detailed explanations are always the best way to support student learning may not be true in all cases. Students' contributions to classroom explanations in mathematics classes promote joint engagement among them and help peers understand concepts better while avoiding hierarchical positioning (Esmonde, 2009). Active learning that promotes critical thinking could effectively address student learning needs (Kim et al., 2013). In active teaching strategies, students don't only take notes or follow directions; they also do some other things (Handelsman et al., 2007). Such teaching strategies that focus on participant-style learning are effective means of increasing academic performance (İlçin et al., 2018). Peer tutoring and cooperative learning are strategies for active learning.

Cooperative learning and peer tutoring in overcoming poor mathematics performance are approaches to organizing classroom activities into academic and social learning experiences. By having cooperative learning activities, students learn from discussion among each other, and they would indirectly adopt new or suitable learning behaviors from the others within the same group. Peer tutoring similarly involves grouping students of similar or different age ranges or abilities in pairs to study together. This strategy saves time over one-on-one tutoring because it involves two students in a small group, and the results of discussions are produced immediately after each activity.

Notwithstanding, there are still challenges to the adoption of these active learning strategies in the classroom (Hora et al., 2012). Instructors' battle some barriers while deploying it to enhance the teaching-learning experience (Finelli et al., 2014; Lund & Stains, 2015; Shadle et al., 2017). Tharayil et al. (2018) identified instructors' convictions about the effectiveness of an active learning approach, time consumption to plan, and student resistance as some of the barriers. Teachers' demographic attributes, including age group and university education, also influence their likelihood to use STEM pedagogies in class (Sellami et al., 2022). Other barriers to implementing active learning strategies are teachers' low competence, overcrowded classrooms, time pressure in the studies, inadequate materials to deliver them, and the examination system encouraging memorization among students (Aksit et al., 2016).

A careful review of previous works showed that researchers have concentrated more on demonstrating how teaching techniques enhance students' performance and the superiority of peer tutoring or cooperative learning over the conventional method. They have not explored deeply the possible factors responsible for this relationship and how to practically adopt the preferred methods in the classroom. This is a gap we have structured this research to address. In this action research study, we have tried to investigate the factors underlying the relationship between teaching methods and academic performance. We also showed how to incorporate an active learning approach (PCL) into the daily mathematics classroom. To achieve this, some selected students were divided into mini groups of four students each to participate in collaborative learning via peer tutoring and then share their experiences with other members of the group in a cooperative learning manner. Another group of students studied individually, and the scores of both groups in a test taken after the treatment were compared. Peer tutoring and cooperative learning strategies have been combined into one in this study and tagged "peer-cooperative learning."

Research Problem

The goal of every teacher is for his students to understand the concepts he has taught at the end of each mathematics teaching and learning lesson. However, it seemed not to happen to students with high mathematics anxiety who also lack the courage to ask questions. This is always revealed lately after they are tested. Statistically, many students fall into this category. Therefore, teachers need to find different ways to help them overcome their mathematics anxiety and make them enjoy learning mathematics. In addition, many students, especially at the secondary education level, avoid the teacher and the lesson and prefer to ask questions and talk with their friends. The effect of this is that they eventually struggle to do well in standard and external mathematics examinations. This suboptimal academic achievement is linked to inefficient teaching methods on the part of teachers, either because of their level of training or because of a lack of motivation. Curriculum design and inadequate educational facilities are also contributing factors. One thing is for sure, teenagers love to confide in peers, so introducing peer-cooperative learning and organizing some appropriate mathematical tasks can enhance their learning.

Research Objective

This study is aimed at establishing a relationship between teaching styles (peer-cooperative learning and conventional teaching) and students' mathematics performances in Ibadan North L.G.A. of Oyo State. It is also intended to demonstrate how to practically incorporate the peer-cooperative learning approach into our day-to-day teaching of STEM.

Research Question

What are the effects of conventional and peer-cooperative learning strategies on students' academic achievement in the fraction concept of mathematics?

Hypothesis

Null Hypothesis (H_0): There is no statistically significant difference in the mean achievement scores of students taught fraction using conventional learning strategies and those taught with peer-cooperative learning strategies.

Significance of the Study

The outcome of the study will serve as a guide for practical application of peer-cooperative learning in STEM teaching. It will also reveal useful insights on the differential effectiveness diverse teaching methods have on students' mathematics performance.

Literature Review

The poor and declining performance of secondary school students in STEM majors in Nigeria calls for urgent attention to achieve the Sustainable Development Goals (SDG) agenda of human development. Sakiyo and Badau (2015) assessed the implication of the trend of students' academic performances in core science subjects in the WASSCE (2008–2012) on the attainment of the Millennium Development Goals in Nigeria. They found that only 46.50% of the students that sat for the exam obtained 1–6 (pass) grades in mathematics, and some other STEM subjects in the WASSCE. Nkpordee and Ibinabo (2022) and Ogunleye (2011) confirmed this trend of poor performance in their studies. To successfully arrest this issue and turn things around, it is important to understand the root cause. Generally, the root cause can be connected to the home (parent or guardian), government, school management (including teachers), students, and the environment. At the center of it all stands the teacher, who is saddled with the primary responsibility of teaching to make the students learn and perform well. The teacher, through his teaching techniques, is directly connected to the students learning and largely influences their performance.

Teaching methods have been strongly linked with students' performances (Ganyaupfu, 2013). A positive correlation exists between teaching methods and students' achievement, particularly in mathematics (Muema et al., 2018). Researchers and educators are aware of this connection and are constantly providing guidance on how to maximize the benefits of the teaching-learning process to boost students' performance. Iyamuremye et al. (2021) opined the adoption of flexible teaching patterns and suitable assessment formats by teachers as a way forward. Similarly, Nkpordee and Ibinabo (2022) posited that teachers' qualifications and experience, as highlighted by Nigerian education policies, are important factors necessary to improve students' academic achievement. Ogunleye (2011) also recommended that more effective means and strategies be required by teachers and educational researchers at the implementation stage of the curriculum to improve student performance. Most of these recommendations revolve around the teacher or teaching methods, making it an important factor to focus on.

Different types of teaching styles and instructional methods have been proposed and are currently being applied by teachers. Newer ones are also constantly evolving, all with the sole aim of improving students' performance. Recently, Awofala and Lawani (2020) applied differentiated instruction by varying and adjusting several instructional methodologies relative to the distinct and diverse needs of the students in an experimental group, and this gave them an edge over those in the other group taught in the conventional style. This happened because the approach is student-

focused, thereby creating cooperation among the students and making the lesson more fascinating and stress-free. This finding successfully demonstrated the power of blending two or more teaching strategies focused on the diverse students' needs and formed our basis for combining peer-tutoring and cooperative learning in this study to examine its effectiveness over the conventional (traditional) teaching approach.

Peer tutoring is a type of formal learning that takes place between students of similar or different age ranges or abilities in pairs or smaller groups under the teacher's supervision, and it benefits the classroom in several ways. Peer tutoring increases student academic achievement (Alegre-Ansuategui & Moliner Miravet, 2017; Alemu, 2020; Kourea et al., 2007; Topping, 2005). It enhances students' learning of content areas more deeply (Topping, 2005) and helps them retain more information (Greenwood, 1997). Azeez et al. (2022) found peer-tutoring as having a significant effect on students' academic achievement and recommended this approach for chemistry teachers to enhance students' achievement. Winterton et al. (2020) described Peer-Led Team Learning (PLTL) as a trend stronger for STEM majors. Peer tutoring is beneficial for reducing middle school students' anxiety about mathematics, regardless of their gender or grade (Moliner & Alegre, 2020).

Peer tutoring has also been used to enhance students' achievement in non-STEM majors. AbdulRaheem et al. (2017) investigated the effect of peer tutoring on students' academic performance in economics, and students in the peer-tutoring group were found to obtain higher scores than those in the conventional instruction group. Peer tutoring as an instructional strategy was also found to be more effective than the conventional lecture method in improving students' academic achievement in financial accounting concepts (Olulowo et al., 2020).

In the case of cooperative learning, students work together towards achieving a common goal. Cooperative learning is a versatile instructional tool for content knowledge and curriculum development. Participation in team activities assists students to gain 'new ideas, insights, connections, and interactions' through discussion of content, which aids better recall of content (Farrell & Farrell, 2009). In mathematics education, the use of cooperative structures in the classroom helps to improve students' problem-solving skills (Barczi-Veres, 2022). Interactive presentations improve narratives presentation and promote mathematics discourse among students (Haj-Yahya & Aegbaria, 2023).

Acar and Tarhan (2006) showed in their study that 11th grade students trained with a cooperative learning strategy performed better in the electrochemistry concept examined than their counterparts exposed to the traditional method. Similarly, Ebrahim (2012) demonstrated that cooperative learning strategies have significantly more positive effects on students' achievement than teacher-centered strategies when he investigated the effect of two teaching strategies, cooperative learning, and teacher-centered approaches, on elementary students' science performance.

Peer tutoring and cooperative learning are proven inclusion methodologies that have been extended to disabled students. Lazarus (2014) showed this in his study on the achievement of students with learning disabilities in mathematics. Other benefits of peer tutoring, cooperative learning, and collaborative teaching are that they can reduce the anti-social behavior of school-aged adolescents, and largely, they are applying these strategies in their classrooms (Eskay et al., 2012).

A unique feature of these two strategies is that they empower students to take charge of their own learning process and profit from it. Teachers facilitate all teaching methods, making them the most influential factor in driving changes to students' mastery-approach orientation in science (Fortus & Touitou, 2021). Therefore, considering the role of the teacher in realizing the goal of STEM integration in promoting experiences that develop skills concepts within and across all its disciplines (National Academy of Engineering and National Research Council, 2014), there is a need for support and guidance for teachers to raise their confidence and competence (Forde et al., 2023). Implementing comprehensive educational reform using required peer-led cooperative learning will help improve students' scores in introductory STEM courses and increase their retention rates in STEM (Salomone & Kling, 2017).

The knowledge of how to deploy this strategy in the classroom effectively is therefore important to achieving its gains. This gap has not been properly addressed by many of the currently available literatures. Numerous action studies have practically demonstrated the effectiveness of this approach, though, but they rarely tailor it to suit the ideal classroom settings. In Nigeria, lessons are generally 30–45 minutes per period, and STEM classes in some cases have double periods once or twice a week. There is a need to demonstrate how to practically incorporate this approach into our local settings within the limited period, and this study has been structured to achieve that.

Methodology

Research Design

An experimental research design was adopted in this action research. The teaching methods (peer-cooperative learning and conventional teaching) were the independent variables, while the students' results in the fraction test formed the dependent variable. The intention was to use the methods to help them build up their confidence levels by working together on the math concept.

Population and Sample

The population for this study was all secondary schools in Ibadan North L.G.A. of Oyo State, Nigeria. The sample consists of one hundred and twenty (n = 120) students selected at random and comprising 32.5% males (n = 31) and 67.5% (n = 89) females.

40 students were randomly selected from the Senior Secondary School 1 class (SSS1 or 10th grade) of each of the three participating schools and divided into two groups of 20 students each. One of the groups is taken to be an experimental group where peer-cooperative learning was applied to facilitate their understanding after receiving normal classroom teaching on fractions, while the students that made up the other control group were only allowed to revise individually and ask teacher or research assistant questions (conventional learning).

The three schools involved were Best Girls High School, Success Grammar School, and Favour Community High School. Best Girls High School is a girls-only school included to check the performance of female students and how the teaching methodologies described can help improve them.

The students were first engaged to acquaint them with the research objectives and the confidential treatment of its outcome to create rapport with them. They were then further interviewed to weed out the uninterested and incompatible sample (e.g., students from other classes different from the SSS1 target).

Research Instrument

Since this action research is to measure the effect of peer-cooperative learning on students' mathematical performance, the researcher discussed a mathematics concept (fraction) with the students, as earlier demonstrated by LaFleur and Bluffs (2010). The students were then allowed some time to revise the concept taught either individually (conventional learning) or in pairs and then cooperatively together (experimental group). The researcher then formulated ten sums (5 multiple-choice objective and 5 theory test questions) titled Fraction Performance Test (FPT) for the students to solve to assess the performance of those that participated in the peer-cooperative learning program and compare it with the score of those that revised individually before taking the test (the control group). The lesson content was developed from the government-approved curriculum for year 10 using approved West Africa Examination Board (WAEC) textbooks, and the questions were sample past questions set by the WAEC for years 9 and 10 or from the textbooks. Experienced mathematics educators and teachers validated the fraction performance test.

The researchers sought the assistance of teachers at the schools visited and some other friends as research assistants for smooth and effective monitoring of the entire research procedure. The fraction is an important concept in mathematics, which is why it was chosen for the study. In fact, Ma and Kessel (2022) believed that the terms whole number and integral unit should only be introduced after the concept of fraction has been introduced. Fractions are foundational concepts in mathematics that are useful in everyday life, and they help students develop other math skills.

Data

The data analyzed in the study were obtained from the assessment test scores from the fraction exercise taken after administering the treatment. The test was prepared by the researchers. The standard test was planned to cover the learning objectives of the topic as designed in the curriculum. We also ensured that the questions were typical samples comparable to those of standardized examinations like WASSCE organized by the West African Examinations Council (WAEC) or the National Examinations Council (NECO).

Treatment

The sample was categorized into two groups: the experimental group and the control group. Each group had 60 students. To make the treatment highly effective, the group of 60 students that received the experimental treatment was further subdivided into mini groups, each comprising four students. While students in the experimental group were exposed to the peer-cooperative learning method, those in the control group were taught in the conventional (traditional) teaching manner.

Statistical Technique

The effectiveness of teaching methods was analyzed using descriptive statistics and a two-way ANOVA approach. Descriptive statistics were used to analyze the estimated marginal means and standard deviations, while the two-way ANOVA was applied to examine whether any significant differences existed between the students' performance (mean scores) for the two teaching methods and the factors that may have influenced the outcome. The two-way ANOVA is applied where it is of interest to compare means of a continuous outcome across two or more factors.

Experimental Procedure

The research involved the selection of 40 students from each of the three different secondary schools. The study was carefully facilitated to last for 45 minutes, in line with the average timing allocated to mathematics and other science subjects in most secondary schools in Oyo State, Nigeria. The following procedure was adopted during the study:

1. Introduction: The intention of the research was first introduced to the selected students. This was to enable them to decide whether to participate in it or opt out. Those that showed interest were retained, while the non-interested ones were excused or replaced. To effectively achieve results, the students must be acquainted with the purpose of the practice. This helps build a supportive classroom environment and helps students learn independently (Brame, 2016).

2. Selection and Sorting: The 40 students were then grouped equally into two groups. The first is the experimental group upon which the effect of the teaching strategies, peer-cooperative learning, was measured. Students in the other group (control) were allowed to study individually and consult with the teacher only in case of any problem or difficulty. The students in the experimental group were paired during the peer tutoring session, and regrouped into 5 sub-groups, each comprising 4 students, during the cooperative learning session.

3. Teaching: The teacher (researcher) chooses a topic (fraction) from the grade level's current curriculum and explains it for twenty-five minutes. The researcher worked through some examples and took questions from the students. He ensures that they all understand and can solve problems on the topic individually. He emphatically asks, "Do you understand?" and "Can you solve problems on this topic when given?" He made sure he satisfies any student's curiosity.

4. Peer tutoring session: The four participants in each of the experimental mini groups are grouped in pairs to study the lesson together first before discussing it together. The concept and definition of tutoring were first discussed, and guidelines on how tutors help their friends were provided. The tutors who are selected need to play the following roles: giving suggestions and providing explanations on the mathematics concept discussed. During the tutoring session, the teacher must always be available to assist the tutors when they have problems and supervise the whole tutoring session. So, the researcher, as the teacher, moderated the tutoring session and ensured that a good relationship existed between the pairs in the focus group.

5. Cooperative Learning Session: The teacher finally dissolves the pairing arrangement and allows the four students in each mini-group to discuss the mathematics concept taught (fraction) among themselves for another ten minutes.

To make cooperative learning effective, the students are empowered to take on roles that are different at the social level. The good student who is most oriented to the task among the group becomes the speaker or facilitator, whereas the other students are the learner, observer, contributor, and checker of the result of the task. However, they were all mutually involved in facing the problem.

6. Testing session: After the teaching session, peer-cooperative learning session, or individual revision session, ten (10) standard test questions were presented to the students to assess them. The question comprises five multiple-choice objective questions and five theory test questions. This session lasted for 30 minutes.

This procedure was carried out in all the three schools. The students who had the peer-cooperative learning experience were expected to score higher than those who studied individually after the lesson. Their results are then compared. The test taken is presented in Appendix I, and the results are in Appendix II.

Findings

Descriptive Statistics

The students' test scores (Appendix II) from the test questions (Appendix I) were the outcome variable. The data analysis was based on descriptive statistics. The one hundred and twenty (n = 120) students who participated in the program were 67.5% female and 32.5% male. Learners' score groups of 85% (n = 102), 14.17% (n = 17), and 0.83% (n = 1) represent the low, moderate, and high band categories, respectively (Figure 1).

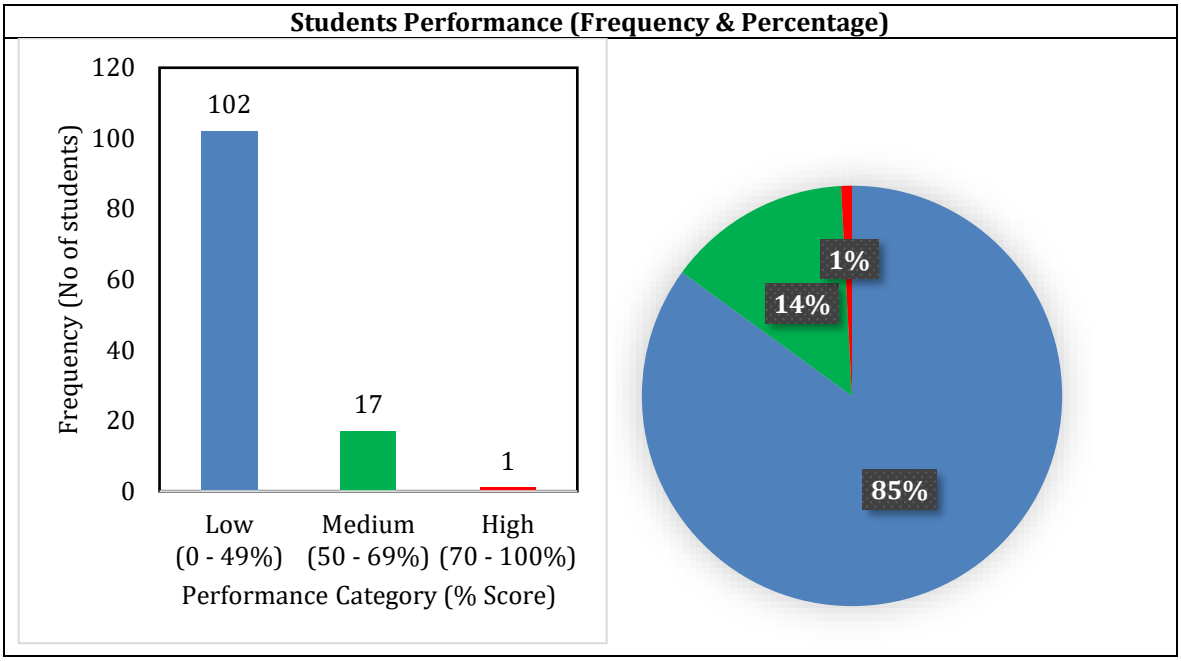

Figure 1. Chart Showing Students' Test Scores

Figure 1 is a pictorial representation of the test scores of students that took part in the study. This figure shows that about 15% had an average score or above while the remaining 85% scored below average. Test scores within the range of [75-100%] are classified as high; [50-74%] are moderate; and [0-49%] means low. Table 1 represents the descriptive statistics summarizing the characteristics of the data set.

Table 1. Descriptive Statistics

		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Assessment Score	PCL	60	3.30	1.51	0.19	2.91	3.69	0.00	7.00
	CL	60	3.10	1.63	0.21	2.68	3.52	1.00	9.00
	Total	120	3.20	1.57	0.14	2.92	3.48	0.00	9.00

Based on the teaching methods investigated, the estimated marginal mean estimates presented in Table 1 reveal that the peer-cooperative learning strategy produced a mean score (mean = 3.30) higher than the conventional teaching approach, which had a mean score of 3.10. The mean estimates of the two instructional strategies discussed fall within the 95% confidence interval band.

Two-way ANOVA Tests of Between-Subjects Effects

In the two-factor ANOVA approach, the computations are organized in an ANOVA table showing the main effect of treatment, the main effect of gender, and the interaction effect. The results of the analysis were obtained with PSPP and presented in Table 2. PSPP is a free, open-source alternative to Statistical Package for the Social Science (SPSS) which is now developed by International Business Machines Corporation (IBM).

Table 2. Two-Factor ANOVA Table for Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig. (*p*-Value)	Partial eta Squared
Corrected Model	53.10	3	17.70	8.55	.000	.181
Gender	5.08	1	5.08	2.46	.120	.021
Teaching Methods (Treatment)	2.01	1	2.01	0.97	.327	.008
Gender*Teaching Method	47.22	1	47.22	22.81	.000	.164
Error	240.10	116	2.07			
Total	1522.00	120				
Corrected Total	239.20	119				

The two-factor ANOVA table (Table 2) comprises four statistical tests. The first test is to examine if there is a difference among the four cell means (Table 3). This gave a highly statistically significant F statistic of 8.55 with a *p* value less than

.001. The null hypothesis is hereby rejected, and the alternative hypothesis is accepted. This significant result then triggers further investigation into the underlying driving factors—treatment (teaching methods), gender, or the interaction between the two. The next three therefore statistical tests evaluate the effect of the treatment, the main effect of gender, and the interaction effect. In this study, there is a highly significant interaction effect ($p < .001$). The main effect of treatment ($p = .327$) and the main effect of gender ($p = .120$) did not reach statistical significance.

We can also conclude from the partial eta squared results that the interaction effect size for gender and teaching method is large and most significant. Comparing gender and teaching methods, the effect size of gender is medium, while the effect size for teaching methods is quite small, which indicates that the interaction between gender and teaching methods is much more significant at predicting students' performance in STEM.

Table 3. Mean Score by Treatment and Gender

Treatment	PCL	CL
Male	2.70	4.32
Female	3.60	2.54

Table 3 contains the mean score for each of the treatments for male and female students, and this is represented in Figure 2. This table shows that the mean score of males is higher in conventional learning than females and lower in peer-cooperative learning.

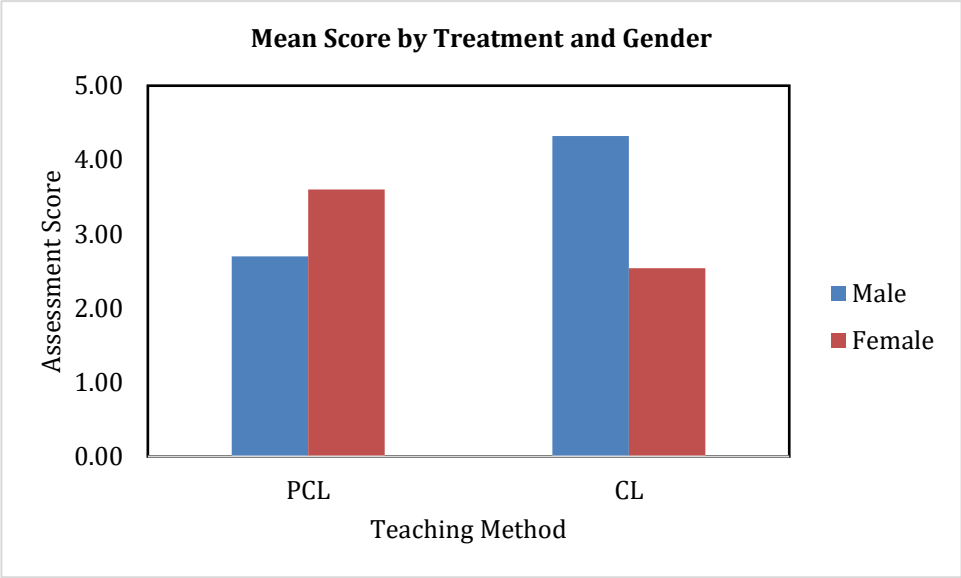

Figure 2. Mean score by Gender and Treatment

Figure 2 is a pictorial representation of the information presented in Table 3. This figure clearly shows the difference in the performance of the students by gender.

Discussion

Performance of Students in Fraction

The descriptive statistics show that only about 15% of the students that took part in the study were able to pass the fraction performance test. This confirms the earlier position of Sakiyo and Badau (2015) and Nkpordee and Ibinabo (2022) on the poor and declining performance of students in mathematics. Fraction is a fundamental concept that is necessary to build other math skills. This poor performance is a pointer to one of the root causes of students' struggles in mathematics.

Research Question

What are the effects of conventional and peer-cooperative learning strategies on students' academic achievement in the fraction concept of mathematics?

Our findings show that effective use of a peer-cooperative learning approach to supplement the conventional approach is key and produces the best student results (Alemu, 2020; Azeez et al., 2022; Barczi-Veres, 2022). Peer-cooperative learning is an action learning strategy that takes care of learners' needs. While the conventional style is more teacher-centered, peer-tutoring and cooperative learning are student-centered, and combining the two as demonstrated here will yield a better result.

The results also show that some students, especially male students, or those above average, are capable of learning individually without distraction and performing well, while others comprehend concepts better when they interact with like-minded colleagues and overcome their low self-efficacy (Alam et al., 2022). The adoption of varying instructional methodologies, as in the case of peer-cooperative learning, or adjusting them to suit students' diverse needs is therefore a productive approach to increasing students' retention rates in STEM majors and boosting performance (Awofala and Lawani, 2020).

Null and Alternate Hypotheses

Null Hypothesis (H_0): There is no statistically significant difference in the mean achievement scores of students taught fraction using conventional learning strategy and those taught with peer-cooperative learning strategy.

Alternate Hypothesis (H_a): There is significant difference in the mean achievement scores of students taught fraction using conventional learning strategy and those taught with peer-cooperative learning strategy.

Analysis of the tests of between-subjects effects shows that there are significant differences between the achievement scores of the two instructional techniques due to the interaction effect between the treatment and gender. The partial eta squared results also match the p-values shown in the output of the ANOVA table and confirm the statistical difference. Table 3 and Figure 2 further help to explain the interaction effect. From Table 3, peer-cooperative learning appears to be a more efficacious treatment for female students, while the conventional approach is more suitable for male students. This finding aligns with and further confirms the submission by Rodger et al. (2007) and Zhan et al. (2015), that female students tend to perform better than their male counterparts in cooperative or group learning sessions. Kaiser and Zhu (2022) findings on the gender differences in mathematics achievement in Shanghai also suggested that girls may perform in mathematics similarly as boys and the gap resulting from mathematical subject areas of higher cognitive demands and tasks where girls are at disadvantage can be closed by adopting appropriate instructional materials and methods, suitable for girls. Peer-cooperative learning can help female students overcome their problems of low self-efficacy and poor performance in mathematics (Alam et al., 2022) and low interest in STEM careers (Wang et al., 2023), which has made STEM programs less attractive to them (Vooren et al., 2022).

Figure 2 shows that the differences in mean score among the treatments can be correlated with the student's gender. Among the male students, the mean score is higher in CL and lower in PCL, while among the female students, the reverse is the case. This point to an interaction effect. Thus, we cannot conclude on the overall treatment effect, as CL is best for male students and PCL for female students. The interaction between gender and teaching methods can therefore influence the performance of students in mathematics and other STEM majors.

Conclusion

Several factors have been attributed to the poor performance of students in STEM majors. Teaching styles are one of the factors researchers have identified as having a great influence on students' overall performance. In this study, we tried to investigate the influence conventional teaching approaches (CL) and peer-cooperative learning (PCL) have on students' assessment scores using two-way ANOVA analysis and establish a relationship between them. Based on this active research, we conclude that:

1. Teaching styles largely influence students' achievement. The best approach that works for a group of students must be carefully selected based on the subject, topic, and students' learning needs. While gender may not necessarily influence students' performance, as earlier demonstrated by numerous researchers, it can influence the choice of teaching strategy.
2. Peer-cooperative learning is effective in teaching mathematics and other STEM majors and especially suitable for female students.
3. The conventional teaching method is also effective and can be beneficial to male students.
4. Peer-cooperative learning can be incorporated into daily teaching to improve the learning experience.

Recommendations

Peer-cooperative learning is recommended for classroom teachers to enhance their teaching and students' learning experiences. Peer-cooperative learning instructional methods should therefore be taught to STEM teachers in training to foster highly effective teaching. The practical approach described in this study is very effective and can be adopted.

For effective results, we recommend that students be allowed to choose their own peer tutors when the teacher is not sure of the best match they can bond with. With adequate knowledge, the teacher should do the selection or guide the students to a match that will benefit them. The teacher must also supervise the session and intervene when necessary.

Teachers are advised to be flexible in their teaching approach and adopt only the active learning strategy that works best for their students or a blend of strategies. No single teaching or learning style can address the diverse needs of students.

Gender can also influence teaching or learning strategy preference, as observed. Further experimental and quasi-experimental studies are therefore recommended to further explore the underlying factors responsible for this observation.

Limitations

This research is limited by the sample size since there are more than fifty schools with well over seven thousand five hundred and fifty tenth grade students in Ibadan North local government area. Considering the deviation of the findings of this research from the popular belief that male students are better in mathematics than their female counterparts, more research needs to be conducted on the use of more suitable instructional methods to bridge the gap and confirm this result.

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Conflict of Interest

The authors declare that they have no competing interests.

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Authorship Contribution Statement:

Aliu: Conceptualization, design, data acquisition, data analysis, and writing. Raheem: Editing/review, critical revision of manuscript, and admin.

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Appendix I – Fraction Performance Test (FPT)

STUDENT NAME: …… CLASS:……

SCHOOL: ……

FRACTIONS

Answer all the Questions.

Time allowed: 30 minutes

PART A

1. $\frac{4\frac{4}{5}-\frac{3}{5}+1}{3+4\frac{4}{5}}$ (a) $\frac{2}{3}$ (b) $\frac{1}{3}$ (c) $\frac{4}{5}$ (d) $\frac{1}{8}$
2. Simplify: $\frac{2}{3}-\frac{3}{5}$ (a) $\frac{1}{2}$ (b) $\frac{1}{6}$ (c) $\frac{4}{5}$ (d) $\frac{1}{15}$
3. A boy has ₦800. He spends ₦160. What fraction of his original money does he have left?
   (a) $\frac{1}{3}$ (b) $\frac{4}{5}$ (c) $\frac{1}{5}$ (d) $\frac{7}{8}$
4. A flagpole 6.3m long is driven 1.4m into the ground. What fraction of the pole is above the ground?
   (a) $\frac{1}{3}$ (b) $\frac{2}{5}$ (c) $\frac{7}{9}$ (d) $\frac{9}{7}$
5. Simplify: $9\frac{1}{3}-5\frac{3}{4}+6\frac{1}{2}$ (a) $8\frac{1}{2}$ (b) $10\frac{1}{12}$ (c) $\frac{7}{8}$ (d) $\frac{1}{3}$

PART B

Please show your workings.

6. Simplify: $2\frac{1}{4}\times 3\frac{1}{2}\div 4\frac{3}{8}$
7. Which is greatest of: $\frac{7}{9},\frac{3}{4},\frac{10}{13}$
8. There are 572 students in a mixed school. $\frac{5}{11}$ of them are boys. How many girls are there?
9. How much less than 6 is the sum of $2\frac{3}{4}$ and $2\frac{4}{5}$
10. A notebook has 128 pages and 88 of them have been used. What fraction of the notebook remains?

Appendix II – Student Assessment Score

S/N	BEST GIRLS HIGH SCHOOL				SUCCESS GRAMMAR SCHOOL				FAVOUR COMMUNITY HIGH SCHOOL			
	PCL		CL		PCL		CL		PCL		CL	
	Score	Gender	Score	Gender	Score	Gender	Score	Gender	Score	Gender	Score	Gender
	10		10		10		10		10		10	
1	4	F	3	F	4	F	1	F	4	F	3	F
2	4	F	3	F	4	F	2	F	7	F	4	F
3	4	F	3	F	4	F	4	F	4	F	3	F
4	2	F	1	F	4	F	3	F	2	M	1	F
5	5	F	2	F	6	F	4	F	2	M	4	F
6	6	F	3	F	2	F	2	F	1	M	2	F
7	5	F	4	F	3	F	4	F	0	M	6	F
8	4	F	2	F	3	M	2	F	1	M	3	F
9	3	F	2	F	1	M	3	F	3	M	3	F
10	5	F	2	F	4	M	1	F	3	F	4	M
11	2	F	3	F	4	M	3	F	3	F	4	M
12	2	F	2	F	4	M	1	F	4	F	6	M
13	3	F	3	F	5	F	4	M	4	F	2	M
14	4	F	2	F	3	F	5	M	2	F	2	M
15	1	F	1	F	3	F	3	M	3	F	7	M
16	1	F	2	F	5	F	2	M	4	M	9	M
17	2	F	1	F	6	M	6	M	4	M	6	M
18	4	F	2	F	6	M	4	M	1	M	2	M
19	4	F	2	F	3	M	4	M	1	M	6	M
20	2	F	2	F	2	M	3	M	2	M	3	M