

Enhancing Students' Academic Performance in Wave Through Cooperative and Discussion Based Instructional Strategies

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Abstract

The concept of waves is a fundamental aspect of physics education, and its understanding is important for students' academic performance in science, technology, engineering and mathematics fields. However, students often struggle to understand wave concepts leading to their poor performance. The main purpose of this study was to examine the effectiveness of Cooperative and discussion instructional strategies on performance of Senior Secondary School Student two (SS2) in Waves. The study adopted quasi experimental research design, specifically pre-test, post-test and non-equivalent control group. The population for the study was 5,240 drawn from all the public senior secondary schools in Dekina Local Government Area of Kogi State. The Sample size for the study was 120 SS2 students who were offering physics from three intact classes. Physics Performance Test (PPT) was used as instrument for data collection. The instrument was validated by experts and its reliability index was 0.81. The data obtained from the study were analyzed using descriptive and inferential statistics. The findings revealed among others that both cooperative and discussion strategies significantly enhanced the performance of students in waves. Based on that it was recommended among others that active learning strategies such as cooperative and discussion strategies should be adopted by physics teachers to teach physics in secondary schools because the methods promote student engagement, collaboration, critical thinking, and deeper understanding of Physics concepts.

Keywords: Cooperative, discussion, strategy, performance, physics students

Introduction

The concept of wave is a fundamental aspect of physics education, and its understanding is important for students' academic performance in science, technology, engineering and mathematics (STEM) fields. However, students often struggle to understand wave concepts leading to their poor performance (Ektina, 2015). To address this challenge, researchers such as Azuka (2019), Uloko (2019), Keller (2022), Chang, (2022) have explored various instructional strategies to enhance students' understanding and academic performance in wave-related topics in public examinations such as West African Senior Secondary Certificate Examination, National Examination Council (NECO) and the likes. Two such strategies that have shown promise are cooperative learning and discussion-based instruction (Johnson & Johnson, 2009). This study therefore, was designed to investigate the effectiveness of cooperative and discussion strategies on academic performance of students in wave-related topics at the senior secondary school level.

Wave connotes a type of motion that produces a disturbance, which is a function of displacement and time that transfers kinetic energy from one point of disturbance to another without any significant movement of the medium itself. Wave is a fundamental concept that appears in various aspects of Physics such as electromagnetism, quantum mechanics, optics and acoustics. Students often struggle to understand wave due to various challenges such as abstract concepts, mathematical complexity, insufficient practical experience, inadequate prior knowledge, inadequate teaching methods, among others (Duit & Treagust, 2020).

Wave as a fundamental concept for understanding STEM plays important roles in advancing the understanding of the natural world and in driven technological innovation. In ultrasound technology, which utilizes high-frequency sound waves to create images of internal organs and tissues that are commonly used for prenatal diagnostics and therapeutic intervention involves the application of waves (Zhang et al. 2022; Ma et al. 2020). Also, in 5G radio waves, which are fundamental components of modern communication systems that enable wireless transmission of information over long distances involves concepts of wave (Rappaport et al. 2022; Hu et al. 2020). Furthermore, wave is widely applied in ocean wave energy converter to generate electricity (Li et al 2022; Astariz et al. 2022; Badru, 2022) Cooperative strategy, also known as collaborative teaching or co-teaching, connotes an instructional approach in which two or more students work together to plan, deliver, and evaluate instruction for a

diverse group of students (Keller, 2022). This method involves students sharing responsibility for learning, utilizing each other's strengths, and collaborating to meet the needs of all learners in the classroom. Cooperative instructional strategy emphasizes teamwork, mutual support, and shared decision-making among educators, with the ultimate goal of enhancing student learning outcomes. Rather than operating in isolation, co-students collaborate closely to create a supportive and inclusive learning environment where all students can thrive (Imoko, 2022).

In furtherance to that, cooperative teaching promotes inclusive education by providing all students, including those with diverse learning needs and abilities, with access to high-quality instruction. By working together, co-teachers can differentiate instruction, provide additional support, and accommodate individual learning styles, ensuring that every student has the opportunity to succeed. Cooperative teaching allows educators to tailor instruction to the needs of individual students, fostering personalized learning experiences. Co-teachers can leverage their unique expertise and perspectives to design instruction that addresses the diverse learning preferences, strengths, and challenges of each student, promoting deeper understanding and engagement (Chang, 2022; Voyer, et al., 2020).

Discussion method is a dynamic and interactive instructional approach that fosters active engagement, critical thinking, and collaborative learning among students. Unlike traditional lecture-based teaching, which emphasizes passive listening and information dissemination, the discussion method encourages students to actively participate in the learning process through dialogue, debate, and reflection (Abimbade, 2019). Discussion method involves facilitating open-ended conversations around key concepts, ideas, and questions related to the subject matter. Students are encouraged to share their perspectives, ask questions, challenge assumptions, and engage in respectful discourse with their peers (Badru, 2022). The role of the educator is to serve as a facilitator, guiding the discussion, posing thought-provoking questions, and providing support as needed to ensure that all students have the opportunity to contribute and learn from each other. Furthermore, the discussion method fosters collaboration and communication skills essential for success in academic, professional, and social contexts (Akinlaye, 2022). By engaging in dialogue with their peers, students learn to articulate their thoughts effectively, listen actively to others' perspectives, and collaborate to solve problems and reach consensus. These communication skills are invaluable in today's interconnected world, where effective collaboration and teamwork are increasingly important.

Academic performance of secondary school students serves as an important factor that determine their higher education goals (Adams, 2022). It is a direct manifestation of learning effectiveness and a valid indicator to evaluate the effectiveness of teaching and learning in senior secondary schools as well as the overall development of students. In this study, academic performance is used as an outcome variable to investigate how to motivate higher students to learn while promoting academic performance. Performance refers to the completion and attainment of a certain level that a student can achieve after a series of training in a subject or a whole course (Kazi, 2022).

Gender differences in learning preferences have been observed in various studies. For instance, some researchers suggest that boys tend to prefer hands-on and active learning experiences, while girls may lean towards collaborative and interactive learning environments. Cooperative strategies, which often involve practical and active interaction, might align more with the learning preferences of male students (Lim & Morris, 2019). On the other hand, discussion method, with its interactive and multimedia components, may appeal to both genders, as it can cater for various learning styles. The effect of cooperative and discussion method strategies on academic performance may differ between male and female students. If the cooperative approach resonates more with male students, they might experience a performance boost when exposed to this teaching method. Conversely, if girls find discussion method more engaging, they could exhibit improved academic outcomes in such environments (Jimoh & Akindoju, 2022).

Studies have revealed that cooperative and discussion strategies have the potential to significantly affect student in educational process (Howland, et al., 2022; Kazi, 2022; Kimberlee, 2020). Both approaches offer unique benefits that can enhance students' interest, motivation, and active involvement in their learning experiences. Cooperative and discussion methods often incorporate interactive elements, multimedia resources, and gamified components, which make the learning process more engaging and enjoyable. Visuals, animations, and interactive simulations can capture students' attention and enhance their understanding of complex concepts of waves. By integrating these two approaches, physics educators can create dynamic and interactive learning environments that encourage critical thinking, collaboration, and self-directed learning (FME, 2022). Hence, the reason for the choice of the two strategies in this study.

However, despite the potential benefits of these innovative teaching approaches, there is need to address several key challenges that might affect their effectiveness in wave-related topics in secondary schools.

The reliance on traditional lecture-based approaches might not be conducive to active learning and critical thinking, contributing to the poor performance of students in examination that borders on wave concepts. It is imperative to address the root cause of poor performance of students in wave by embracing innovative teaching methods, such as cooperative and discussion strategies. Furthermore, studies have revealed the effectiveness of cooperative and discussion instructional strategies in other subjects and the use of the two strategies in a single study in any branch of Physics remains scanty. Hence, there is need for further study of the effectiveness of these two strategies in wave-related topic. Therefore, the study intends to investigate the effectiveness of cooperative and discussion strategies on academic performance of senior secondary school students in wave-related topics in Kogi State

Research Questions

The following research questions were generated to guide the study;

1. What are the differences between the pre-test and post-test performance mean scores of SS2 students taught wave using cooperative strategy and conventional lecture method?
2. What are the differences between the pre-test and post-test performance mean scores of SS2 students taught wave using discussion strategy and conventional lecture method?
3. What are the differences between the pre-test and post-test performance mean scores of SS2 students taught wave using cooperative and discussion strategies?
4. What are the differences between the pre-test and post-test performance mean scores of male and female SS2 students taught wave using cooperative and discussion strategies?

Hypotheses

The following hypotheses were formulated and tested at 0.05% level of significance

1. There is no significant difference between the post-test performance mean scores of SS2 students taught wave using cooperative learning strategies and those taught using conventional lecture method.
2. There is no significant difference between the post-test performance mean scores of SS2 students taught wave using discussion strategy and those taught using conventional lecture method.

3. There is no significant difference between the post-test performance mean scores of SS2 students taught wave using cooperative learning method and those taught using discussion learning method

Methodology

The research design for this study was quasi-experimental design involving a pretest, posttest, and control group design. The population of the study comprised all senior secondary school two (SS2) Physics students in Dekina Local Government Area of Kogi State with 5,240 male and female. The sample size for the study consisted of 120 SS2 Physics students drawn from three intact classes. The instrument used for data collection was Physics Performance Test (PPT), which was developed by the researcher and validated by experts in Physics Education and Tests and Measurements. Its reliability coefficient using Kuder Richardson 20 formula was 0.81. The PPT consisted of 30 multiple-choice objectives test items A-D drawn from the concepts of waves. There are three groups for the study; experimental group 1 and 2, and control group. The experimental group 1 was taught waves using cooperative strategy, while the experimental group 2 was taught waves using discussion strategy. The control group was taught using the conventional lecture method. The treatment lasted for 7 weeks. The three groups were subjected to pre-test to ascertain their entry behaviour before the commencement of the treatment. After the 7 weeks treatment, the three groups were post-tested. The results of the pre-test and post-test were sorted out and analyzed using descriptive and inferential statistics. The descriptive and inferential statistical techniques were used to analyze the data. The research questions were answered using mean and standard deviation. The hypotheses were tested at 0.05 level of significance using t-test and Analysis of Variance (ANOVA)

Results

Research Question One

What are the differences between the pre-test and post-test performance mean scores of SS2 Physics students taught waves using cooperative strategy and conventional lecture method?

Table 1: Pre-test and Post-test Performance Mean Scores of SS2 Physics Students in the Experimental 1 and Control Group.

Variable	N	Pre-test		Post-test		Mean Gained
		Mean	St.D	Mean	St.D	
Cooperative Group	45	25.21	2.96	32.14	2.89	6.93
Control Group	42	24.13	2.90	25.21	2.69	1.08

Table 1 showed that the pre-test performance mean scores of students taught wave using cooperative strategy and those taught the same concept using lecture method were 25.21 and 24.13 with standard deviations of 2.92 and 2.94, while the post-test performance mean scores of students taught the same concept using cooperative strategy and lecture method were 32.14 and 25.21 with standard deviations of 2.89 and 2.96 respectively. This implies that cooperative strategy enhanced students' performance than lecture method. The implication of this finding is twofold. It indicates that cooperative method was more effective in enhancing students' performance in wave than conventional lecture method.

Research Question Two

What are the differences between the pre-test and post-test performance mean scores of SS2 Physics students taught waves using discussion strategy and conventional lecture method?

Table 2: Pre-test and Post-test Performance Mean Scores of SS2 Physics Students in the Experimental Group 2 and Control Group.

Variable	N	Pre-test		Post-test		Mean Gained
		Mean	St.D	Mean	St.D	
Discussion Group	33	33.19	1.02	42.21	1.89	3.86
Control Group	42	32.21	1.11	33.11	2.69	0.9

Table 2 revealed that the pre-test and post-test performance mean scores of students taught wave using discussion method and those taught the same concept using lecture method were 33.19 and 32.21 with standard deviations of 1.89 and 2.69 respectively. Furthermore, the post-test performance mean scores of students taught wave using discussion and lecture methods were 42.21 and 33.11 with standard deviations of 1.89 and 2.69. The substantial difference in the mean scores suggested that students who were taught wave using discussion method performed higher than their counterparts who were exposed to lecture method. The implication of this finding is that discussion method was more effective in enhancing students' performance in wave than conventional lecture method.

Research Question Three

What are the differences between the pre-test and post-test performance mean scores of SS2 Physics students taught waves using cooperative and discussion strategies?

Table 3: Pre-test and Post-test Performance Mean Scores of SS2 Students in the Experimental Groups.

Variable	N	Pre-test		Post-test		Mean Gained
		Mean	St.D	Mean	St.D	
Cooperative	45	12.12	1.02	36.36	2.69	24.24
Discussion	33	11.22	1.59	28.99	3.43	17.77

Table 3 indicated that pre-test performance mean scores of students in cooperative and discussion groups were 12.12 and 11.22 with standard deviations of 1.02 and 1.59, while the post-test were 36.36 and 28.99 with standard deviations of 2.69 and 3.43 respectively. The analysis in Table 3 revealed that students taught using cooperative learning strategy performed higher than their counterparts who were taught using discussion learning strategy. Though the two strategies enhanced students' performance in waves, the analysis revealed that cooperative strategy showed more effectiveness in enhancing students' performance in wave.

Research Question Four

What are the differences in the pre-test and post-test performance mean scores of male and female SS2 Physics students taught waves using cooperative and discussion strategies?

Table 4: Pre-test and Post-test Performance Mean Scores of Male and Female SS2 Physics Students in the Experimental Groups

Variable	Gender	N	Pre-test		Post-test		Mean Gained
			Mean	St.D	Mean	St.D	
Cooperative	Male	25	21.4	3.82	39.01	2.49	9.08
	Female	20	33.8	2.79	48.09	1.27	
Discussion	Male	18	20.8	3.32	21.47	2.16	1.25
	Female	15	21.9	3.11	22.72	2.11	

Table 4 showed that the pre-test performance mean scores of male and female students in cooperative group were 21.40 and 33.80 with standard deviations of 3.82 and 2.79, the post-test performance mean scores were 39.01 and 48.09 with standard deviations of 2.49 and 1.27 respectively. Similarly, the analysis in Table 4 indicated that the pre-test and post-test performance mean scores of male and female students in discussion group were 20.80, 21.90, 21.47, and 22.72 with standard deviations of 3.32, 3.11, 2.16 and 2.11. The analysis revealed that the female students performed higher in experimental group 1 and 2 than their male counterparts. This suggests that while both genders benefited from cooperative and discussion learning strategies, female students are to be strongly advised to study physics. Sanni and Ochea (2022) explored gender differences in small-group discussion settings and stated that females often exhibit stronger collaborative skills and participation in discussion classroom setting.

Testing Hypotheses

Hypothesis One: There is no significant difference between the Post-test performance mean scores of the SS2 students in cooperative and control Groups.

Table 5: One-way ANOVA Posttest Result of Students' Performance in the Cooperative and Control Groups

Source of Variation	Sum of Squares	Df	Mean Square	F	P-value
Between Groups	20614.411	2	10412.211		
		85		38.210	.000
Within Groups	3245.652		256.994		
Total	23860.063	87			

P < 0.05

The analysis in Table 5 revealed a calculated F (2, 87 = 38.210, P = 0.000). From the analysis, the F-cal is greater than the P-value of 0.000. Since F-cal was greater than P-value, then the null hypothesis was rejected and the alternative hypothesis was upheld. This implies that there was a significant difference in the post test performance mean scores of students in the experimental and control groups.

Hypothesis Two: There is no significant difference between the post-test performance mean scores of SS2 students exposed to discussion and conventional lecture method.

Table 6: t-test Analysis of Post-test Performance Mean Scores of SS2 Physics Students in Discussion and Control Groups

Test	Group	N	Df	Mean	SD	t-cal	P-value (2tailed)
Posttest	Discussion	33		42.21	1.89	28.02	0.000
	Control	42	73	33.11	2.69		

P < 0.05

The analysis in Table 6 revealed that P-value of 0.000 was less than the significant level set at 0.05. Since P-value of .000 is less than the significance level set at 0.05, the null hypothesis was rejected. This means that there was a significant difference between the posttest performance mean scores of SS2 students in the discussion and control groups. This was due to the treatment which the students in discussion group received.

Hypothesis Three: There is no significant difference between the post-test performance mean Scores of SS2 Physics students in cooperative and discussion groups.

Table 7: t-test Analysis of Posttest Performance Mean Scores of SS2 Physics Students in Cooperative and Discussion Groups

Test	Group	N	Mean	SD	df	t-cal	P-value (2tailed)
Posttest	Cooperative	45	36.36	2.69	76	4.83	0.000
	Discussion	33	28.99	3.43			

P < 0.05

The analysis in Table 7 indicated that P-value of 0.000 was less than the significant level set at 0.05 at $df = 76$. Since the P-value is in the critical region of rejection ($p < 0.05$), then the null hypothesis was rejected. This implies that there was a significant difference between the post-test performance mean scores of SS2 students exposed to cooperative strategy and those exposed to discussion strategy. The Scheffe post hoc test was presented in Table 8. The Scheffe post-hoc test in Table 8 confirmed that the difference between the post-test performance mean scores of students exposed to cooperative and discussion strategies (I-J) was not significant. By implication, the cooperative and discussion strategies enhanced students' performance in waves, although cooperative strategy was more effective.

Table 8: Scheffe Post-hoc Comparism of Post-test Physics Mean Scores of Cooperative and Competitive Groups

Variable	X ₁	X _j	Mean Difference i-j	Std Error	Levene F- Statistic	Scheffe Sig P
Cooperative	12.12	36.36	-24.24	0.35	0.706	0.814
Discussion	11.22	28.99	-17.77	0.40		

Discussion of Findings

The analysis in Table 5 revealed that there is a significant difference in the post-test performance mean scores of students taught waves using cooperative strategy and those taught the same concept using conventional lecture method. The findings of the study is in line with Imoko (2022), Iyamu and Otote (2022) who found out that cooperative learning not only promoted higher performance but also enhanced social skills and positive interdependence among students.

The analysis in Table 6 indicated that there is a significant difference in the post-test performance mean scores of students taught waves using discussion method and those taught the same concept using conventional lecture method. The findings of this study is in line with Kazi (2022) and Azuka (2019) who found out that discussion method led to significant higher learning outcomes compared to lecture method. This suggests that active involvement and participation through discussions can enhance understanding and retention of Physics concepts. The analysis in Table 7 revealed a significant difference in the post-test performance mean scores of students who were taught waves using cooperative and discussion strategies. However, the Scheffe post-hoc test in Table 8 confirmed that the difference between the post-test performance mean scores of students exposed to cooperative and discussion strategies (I-J) was not significant. The findings of this study is in line with Khaled and Chiodo (2022) and Kehinde (2022) who found out that cooperative and discussion learning methods significantly improve academic performance of students compared to traditional methods. They noted that cooperative and discussion strategies foster active engagement, promotes critical thinking, and enhances social interactions among students, leading to better learning outcomes.

Conclusion

Findings from the study revealed that cooperative method was effective in enhancing academic performance of secondary school students in Physics than conventional lecture method. Discussion method was likewise effective in enhancing academic performance of students in wave than conventional lecture method. However, it was revealed that cooperative method was more effective in enhancing academic performance of students in wave than discussion method. In conclusion, cooperative and discussion strategies are generally effective in enhancing academic performance of students compared to traditional lecture-based approach as confirmed by the Scheffe post-hoc test.

Recommendations

Based on the findings of this study, the following recommendations were provided.

1. Encourage the adoption of active learning strategies such as cooperative learning and discussions in educational settings. These methods promote student engagement, collaboration, critical thinking, and deeper understanding of Physics concepts.
2. The specific learning objectives, subject matter, and students' demographics should be considered when selecting instructional methods that would address the diverse learning styles and preferences among students.
3. Addressing gender-specific differences in educational outcomes by promoting inclusive practices in the classroom provide opportunities for all students, regardless of gender, to actively participate and contribute to discussions and cooperative activities. Physics educators should be mindful of creating supportive learning environments that accommodate various learning styles and preferences.

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