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Effects of Metacognitive and Lecture Instructional Methods on Physics Students' Achievement in Delta State

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Abstract

This study compared the effects of metacognitive and lecture instructional methods on physics students' achievement in Delta State. The study was guided by three research questions and three null hypotheses. A quasi-experimental design, pre-test, post-test, planned variation design using a 2 x2 factorial design adopted for the study. The population for this study comprised 29,817 Senior School II (SS II) students offering physics in all the public secondary schools in Delta State for the 2023/2024 session. A sample of 282 SS2 students were drawn from six mixed secondary schools in Delta State. A multi-stage sampling technique was used for the selection of the schools. Data for the study was collected using Physics Achievement Test (PAT) with reliability index of 0.85. Data were analysed using Mean and Standard Deviation statisticst-test and Analysis of Covariance (ANCOVA). All hypotheses were tested at 0.05 alpha level. The findings of the study are: (i)There was a significant difference in the academic achievement mean scores of physics students taught with metacognitive and lecture instructional methods. (ii)There is no significant difference in the mean achievement scores between male and female students taught physics using metacognitive instructional strategy. (iii) There is no significant interaction effect of instructional strategies and sex on students' academic achievement in physics. Based on the findings, it is concluded that instructional strategy significantly affects students' academic achievement. It was recommended that physics teachers in secondary schools in Delta State should adopt the metacognitive method as a primary strategy for improving achievement outcomes.

Keywords: Metacognitive, Lecture Method, Sex, Physics, Achievement

Introduction

Physics is a branch of science that deals with the study of matter, energy, and the interactions between them. It encompasses the fundamental principles that govern the behaviour of the physical world. Physics, as a subject, serves as a springboard for Nigeria's much-needed scientific, technical and socioeconomic advancement. The general objectives of physics at the secondary school level as stipulated in the National Policy of Education include to: (i)provide basic literacy of physics for functional living in the society; (ii) acquire basic concepts and principles of physics as a preparation for further studies; (iii) acquire essential scientific skills and attitudes as a preparation for the technological applications of physics; and (iv) to stimulate and enhance creativity (FGN, 2018) [6].

The study of physics is essential for any nation striving to maintain its leadership in the global community. Indeed, a nation's technological potential can be more accurately assessed by the quality of its physics education, as the technological advancement of its citizens is fundamentally grounded in a solid understanding of physics (Ogunleye, 2021) [17]. Today, the importance of physics education is greater than ever before in history. Physics is an exciting intellectual adventure that inspires young people and expands the frontiers of our knowledge about nature. Physics generates the fundamental knowledge needed for the future technological advances that will continue to drive the economic engines of the world. Physics contributes to the technological infrastructure and provides the trained personnel needed to take advantage of scientific advances and discoveries. Physics extends and enhances our understanding of other disciplines, such as the earth, agricultural, chemical, biological, and environmental sciences, as well as astrophysics and cosmology subjects of substantial importance to all people in the world. Physics improves the quality of life by providing the basic understanding necessary for developing new instrumentation and techniques for medical applications such as computer tomography, magnetic resonance imaging, positron emission tomography, ultrasonic imaging, and laser surgery. (Trisma *et al*., 2020) [23].

Numerous teaching strategies have been developed and put to the test over the years. Some are still regarded as rather successful, even though many have been deemed inappropriate for secondary school instruction. It is well recognized that instructional methods have a substantial impact on students' academic achievement across a range of subject areas. Students may get interested in a topic because of the teacher's teaching methods. However, it seems that a large number of secondary school physics teachers are either unaware of or lack a thorough comprehension of the numerous innovative teaching methods for physics instruction. For this reason, the lecture method is often used while teaching physics (Josiah *et al.,* 2021) [10].

The lecture method is an instructional strategy in which the teacher presents a verbal discourse on a particular topic or concept to the learners. In the lecture method, teachers often present preplanned lessons to the students with little or no instructional materials. Lecture method involves a verbal presentation of ideas, concepts, generalizations and facts. The practice in this method is that of spoon-feeding the learners with information or facts. In its purest form, the lecture method is a one-way interaction in which the teacher speaks to the students in an authoritative manner, and the students have no chance to raise questions or make comments throughout the class (Mbonyiryivuze, *et al*. 2019) [12]. The lecture method advantages include the ability to introduce new subject matter or offer overview summaries to students, the ability to teach groups of any size, and the ability for the instructor to cover a lot of ground in a short amount of time. Being a teacher-centre method, the lecture method makes the teacher function as a classroom lecturer, presenting information about a concept to the students who then passively receive the knowledge being presented and making the teacher feel in-charge in the classroom setting. As good as the lecture method seems to be, it has some drawbacks that can hinder effective learning among students. According to Sharma (2020) [22], the lecture method does not take into account individual needs and feelings, making students passive learners, not giving students the chance to practice what they learn, not taking into consideration individual differences, and not developing students' reasoning power. These identified limitations and criticisms levied against the lecture method paved the way for a shift in research efforts from the lecture method to an innovative instructional method that could enable individual students to create their own meanings from the experiences they have. Metacognitive and flipped-classroom methods are two examples of innovative instructional methods that could enable individual students to create their own meanings from the experiences they have.

Metacognitive teaching method is a sequential process that teachers uses to control cognitive activities, and to ensure that a cognitive goal is achieved. These processes help to regulate and oversee learning, and consist of planning and monitoring cognitive activities, as well as checking the outcomes of those activities. This method involves guiding students to think about how they learn, monitor their own understanding, and make adjustments as needed. One of the feature of metacognitive method is that Students are encouraged to reflect on their thoughts and actions related to learning (Nelson & Narens, 2020) [14]. Another feature of Metacognitive teaching method is that it is a learner-centered approach to training that in which students are empower to reflect on their own thinking via the use of metacognitive teaching tools. Meta-cognitive instructional strategy according to Nzeadibe *et al.,* (2019) [15] encourages actions which go beyond purely cognitive devices and which provide learners to coordinate their own learning process. The author further stated that, meta-cognitive strategies are sequential processes individuals are to control cognitive activities, and to ensure that a cognitive goal is achieved. These processes help to regulate and oversee learning, and consist of planning and monitoring cognitive activities, as well as checking the outcomes of those activities. Research findings of some studies that employed meta-cognitive instructional strategies show that meta-cognitive strategy enhances students' achievement in various subjects than conventional lecture method. For instance, Xiying and Gang (2019) [25] found out that students achieved higher in English when taught using meta-cognitive strategies than when taught using lecture method. Similarly, students' achievement in Biology was enhanced and effective correlates of success in college anatomy and physiology when meta-cognitive approach was used (Okoza, *et al.,* 2013) [19].

The effects of metacognition and lecture methods on students' achievement may vary across sex. The term "sex" refers to biological characteristics of being male or female. Sex can influence various aspects of human life, including educational outcomes, where differences may emerge in how males and females respond to certain teaching methods. When comparing the effects of these teaching methods across sexes some studies (Odewumi & Yusuf, 2018; Ikwuka & Okoye, 2021) [16, 8] found no evidence of a significant relationship between sex and achievement when exposed to instructional methods whereas others (Albalawi, 2018; Chebotib, *et al*., 2020; Ma, 2023) [3, 4, 11] found a substantial relationship between sex achievement, with males scoring higher than females in the study. This means the issue of sex and academic achievement in relation to the instructional method used is yet to be concluded, thus in this study, an attempt will be made to compare the effects of metacognition, flip classroom and lecture method on student academic achievement and critical thinking in physics in Delta State, and also to determine whether the effects will be sex dependent.

Research Methods

Design of the Study

A quasi-experimental design, pre-test, post-test, planned variation design using a 2x2 factorial design adopted for the study. *Quasi-experimental design* involving plan variation was used because the study only interested in comparing the effectiveness of two instructional Strategies-Metacognitive, and Lecture Instructional Methods, with sex at two levels (male and female).

Population of the Study

The population for this study comprised a total of 29,817 Senior School II (SS II) students offering physics in all the public secondary schools in Delta State for the 2023/2024 session (Ministry of Basic and Secondary Education, Asaba, 2023).

Sample and Sampling Techniques

A sample of 282 SS2 students were drawn from six mixed secondary schools in Delta State. Multi-stage sampling procedures which comprise simple sampling technique was employed in selecting the sample for the study. At the first stage three out of the twenty-five local government were randomly selected. At the second stage six secondary schools were selected, two from each of the selected local government areas using simple random sampling method. Finally, treatment method (instructional methods) were randomly assigned to each selected school in their intact classes. To assign treatment conditions to the sample schools, the schools were first coded as A, B and C. The instructional methods were written on three identical square papers, rumpled and mixed together. The instructional approach that was picked was assigned to the sample schools in the order of their numbers.

Research Instrument

The instrument that was used for the study are Physics Achievement Test (PAT). Both PAT was used for collection of data during the pretest and posttest. The PAT consists of two sections. Section A contains instruction on the students' personal information (such as sex). Section B has 50 multiple-objective test-items with option letters A-D, The items in the Physics Achievement Test (PAT) were selected from SSCE past questions in physics. The validity and reliability of the Physics Achievement Test (PAT) was sort of checked before it was used in the actual study. Face validity was looked at by two Science Education specialists plus one Measurement and Evaluation expert who examined the relevance, and clarity of the items. As for construct validity, it was done via item analysis with 50 SS II students from secondary schools in Onitsha, Anambra State. The difficulty indices moved from 0.44 up to 0.66, and the discrimination indices ranged from 0.45 to 0.75, so it suggested the test questions were fine and able to tell apart high and low performing students. Content validity was also handled by preparing a table of specification based on six Physics areas taken from the NERDC SS II Physics curriculum, that is, production and propagation of waves, types of waves, properties of waves light waves, and sound waves. Reliability was determined by using the internal consistency approach. Then the PAT was given to 50 SS II students across five secondary schools in Onitsha. Finally, the Kuder–Richardson Formula 21 (KR-21) produced a reliability coefficient of 0.85, which means the instrument had a strong dependability level, and it was fit for use in this study.

Treatment Procedure

The whole treatment procedure was run in three phases. At first, the participating schools were randomly allocated to either the metacognitive instructional method, or the lecture method. The instructional methods themselves were coded and then assigned via a balloting process, so that the intact classes within the chosen schools got the designated treatment. By doing that, the study ended up with experimental and control groups that could then be compared. Then, in a second part, the research assistants (Physics teachers), were trained before any implementation actually started. Teachers assigned to the metacognitive group went through a four-day training programme that leaned heavily on the theoretical foundations, the procedures, and the classroom usage of the metacognitive strategy. That training had practical sessions as well, meant to support the effective carry out of the treatment. Meanwhile teachers in the lecture group received no further training, since they were already comfortable with the usual lecture method. The final phase involved the actual classroom implementation of the treatments. Lesson plans covering the selected Physics topics were provided to the teachers one week before the intervention. The teachers then taught the students for six weeks using either the metacognitive instructional method or the lecture method, following the prescribed instructional procedures. At the end of the treatment period, the Physics Achievement Test (PAT) was re-administered as a post-test to assess the effect of the instructional methods on students' academic achievement.

Method of Data Analysis

In order to answer the research questions, the data that were collected through the PAT analysed using Mean and Standard Deviation statistics. Hypotheses were tested using One-way Analysis of variance (ANOVA and Analysis of Covariance (ANCOVA). In the analysis, hypothesis one and six were tested using Analysis of variance, hypothesis 2-4 and 7-9 were tested using independent sample t-test and hypothesis five and ten were tested using Analysis of Covariance (ANCOVA). All hypotheses were tested at 0.05 alpha level.

Results and Discussion

Presentation of Results

Research Question 1: What is the difference in academic achievement mean scores of physics students taught with metacognitive, flipped-classroom and lecture instructional strategies?

Table 1: Analysis of the Difference in Posttest Academic Achievement Mean Scores of Physics Students Taught with Metacognitive, Flipped-Classroom and Lecture Instructional Strategies using using Mean and Standard Deviation

Instructional Strategies	N	Mean	Std. Deviation
Metacognitive	89	56.31	9.62
Lecture	99	46.12	5.12
Total	188		

Table 1 shows the posttest academic achievement mean scores of physics students taught with metacognitive and lecture instructional strategies. The table reveals that students in the metacognitive instructional strategy group had a posttest mean score of 56.31 with a standard deviation of 9.62 and a standard deviation of 10.02 and students in the lecture instructional strategy group had a mean score of 46.12 with a standard deviation of 5.12. A careful analysis of the table shows that in the metacognitive group than those in the lecture instructional strategy group.

To ascertain if the mean difference is significant, Ho_1 was tested with independent sample t-test and presented in Table 2.

Hypothesis 1: There is no significant difference in difference in academic achievement mean scores of physics students taught with metacognitive and lecture instructional strategies.

Table 2: Independent Samples t-test comparing the Pretest Academic Achievement Mean Scores of Physics Students Taught with Metacognitive and Lecture Instructional Strategies at Pretest

Instructional variables	N	Mean	Std. Deviation	df	t-cal.	Sig. (2-tailed)	Remark
Metacognitive	89	13.20	2.869	87	0.12	.905	Null hypothesis not rejected
Lecture	99	13.24	1.585				
Total	188						

Table 2 presents the summary of the independent samples t-test analysis comparing the pretest academic achievement mean scores of Physics students assigned to the metacognitive and lecture instructional strategy groups. The table shows that the p-value (.905) is greater than 0.05. With this result, the null hypothesis was not rejected. Thus, there is no significant difference in the pretest academic achievement mean scores of Physics students assigned to the metacognitive instructional strategy group and those assigned to the lecture instructional strategy group. This finding indicates that both groups were academically equivalent before the commencement of the treatment. With this Independent Samples t-test statistic becomes the appropriate statistics to be used to test Ho_1 and this this shown in Table 3.

Table 3: Independent sample t-test analysis of the Academic Achievement Mean Scores of Physics Students Taught with Metacognitive and Lecture Instructional Strategies at post test level

Instructional strategies	N	Mean	Std. Deviation	df	t-cal.	Sig. (2-tailed)	Remark
Metacognitive	89	56.31	9.62	87	8.6	.00	Null hypothesis rejected
Lecture	99	46.12	5.12				
Total	188						

Table 3 presents the summary of the independent samples t-test analysis of the difference in the mean achievement scores of students taught Physics using the metacognitive instructional method and those taught using the lecture method. The table shows that the p-value (.000) is less than 0.05. With this result, the null hypothesis was rejected. Thus, there is a significant difference in the mean achievement scores of students taught Physics using the metacognitive instructional method and those taught using the lecture method. Students taught using the metacognitive instructional method (Mean = 56.31, SD = 9.62) achieved significantly higher scores than those taught using the lecture method (Mean = 46.12, SD = 5.12), indicating that the metacognitive instructional method was more effective in enhancing students' achievement in Physics.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught physics using metacognitive instructional strategy?

Table 4: Analysis of the difference between the Mean Achievement Scores of Male and Female Students taught Physics using Metacognitive Instructional Strategy using Mean and Standard Deviation

Sex	N	Mean	Mean Difference	Std. Deviation
Males	57	56.89	1.61	8.15
Females	32	55.28		11.87
Total	89			

Table 4 presents the analysis of the mean achievement scores of male and female students taught Physics using the metacognitive instructional strategy. The table shows that male students (N = 57) had a mean achievement score of 56.89 with a standard deviation of 8.15, while female students (N = 32) recorded a mean score of 55.28 with a standard deviation of 11.87. The mean difference between the two groups was 1.61. To find out whether the mean difference is significant, Ho_2 was tested with independent sample t-test and presented in Table 5.

Hypothesis 2: There is no significant difference between the mean achievement scores of male and female students taught physics using metacognitive instructional strategy.

Since no significant difference was found in Table 4.2, independent sample t-test was used to test Ho_2.

Table 5: Independent sample t-test analysis of the Difference Between the Mean Achievement Scores of Male and Female Students taught Physics using Metacognitive Instructional Strategy

Sex	N	Mean	Std. Deviation	df	t-cal.	Sig. (2-tailed)	Remark
Males	57	56.89	8.15	87	.76	.45	Null hypothesis not rejected
Females	32	55.28	11.87				
Total	89						

Table 5 is a summary of independent sample t-test analysis of the difference between the mean achievement scores of male and female students taught physics using metacognitive instructional strategy. The table shows that the p-value (.45) is greater than 0.05. With this result, Ho_2 was not rejected. Thus, there is no significant the difference between the mean achievement scores of male and female students taught physics using metacognitive instructional strategy.

Research Question 3: What is the interaction effect of instructional strategies and sex on students' academic achievement in physics?

Table 6: Analysis of the Interaction Effect of Instructional Strategies and Sex on Students' Academic Achievement in Physics using Mean and Standard Deviation

Instructional Strategies	Sex	N	Mean	Mean difference	Std. Deviation
Metacognitive	Males	57	56.65	0.93	8.84
	Females	32	55.72		11.00
Lecture	Males	55	46.71	1.35	5.02
	Females	44	45.39		5.19

Table 6 presents the mean and standard deviation analysis of the interaction effect of instructional strategies and sex on students' academic achievement in Physics. The results show that male students taught using the metacognitive instructional strategy obtained a mean achievement score of 56.65 (SD = 8.84), while their female counterparts obtained a mean score of 55.72 (SD = 11.00), resulting in a mean difference of 0.93. Similarly, male students taught using the lecture instructional strategy recorded a mean achievement score of 46.71 (SD = 5.02), while the corresponding mean score for female students was lower, with a mean difference of 1.35. The small mean differences observed between male and female students within each instructional strategy indicate that sex had minimal influence on students' academic achievement.

Hypothesis 3: There is no significant interaction effect of instructional strategies and sex on students' academic achievement in physics?

Table 7: ANCOVA Summary of the Interaction Effect of Instructional Strategies and Sex on Students' Academic Achievement in Physics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	5060.253ᵃ	4	1265.063	22.008	.000
Intercept	11544.099	1	11544.099	200.830	.000
Pretest	130.013	1	130.013	2.262	.134
instructional Strategies	4608.213	1	4608.213	80.168	.000
Sex	51.114	1	51.114	.889	.347
Instructional Strategies * Sex	2.931	1	2.931	.051	.822
Error	10519.215	183	57.482		
Total	503548.000	188			
Corrected Total	15579.468	187			
a. R Squared = .325 (Adjusted R Squared = .310)					

Table 7 revealed the ANCOVA summary of the interaction effect of instructional strategies and sex on students' academic achievement in Physics. The result shows that the computed F-value for the interaction between instructional strategies and sex is 0.051 with a corresponding p-value of 0.822. Testing the null hypothesis at an alpha level of 0.05, the p-value (.822) was greater than 0.05; hence, the null hypothesis was not rejected. This implies that there is no significant interaction effect of instructional strategies and sex on students' academic achievement in Physics. Therefore, the effectiveness of the instructional strategies on students' academic achievement did not vary according to students' sex.

Discussion of Findings

The first finding showed a significant difference in the academic achievement mean scores of Physics students taught using metacognitive and lecture instructional strategies. Specifically, students exposed to the flipped-classroom strategy recorded the highest mean scores, followed by those taught with the metacognitive strategy, while students in the lecture method group showed the lowest academic achievement. This result suggests that the metacognitive strategy is the most effective in enhancing students' academic achievement in Physics. Its effectiveness maybe attributed to its emphasis on self-regulation, reflection, and awareness of one's cognitive processes during learning. In contrast, the lecture method, being primarily passive and teacher-centered, appears less effective in promoting meaningful academic gains. This finding is in agreement with Yusuf (2014) [26] and Ugwuanyi (2016) [24] and who highlighted the superiority of student-centered methods over lecture method in improving students' academic achievement. The finding also aligns with Iserameiya and Uwameiye (2018) [9] who found that metacognitive instruction promotes higher academic achievement compared to traditional teaching methods.

The second finding revealed that there was no significant difference in the mean achievement scores between male and female students taught Physics using the metacognitive instructional strategy. This suggests that the metacognitive approach to teaching Physics is effective across both sexes and provides an equitable learning experience. The strategy likely creates a balanced learning environment where both male and female students are equally engaged in reflecting on their thinking, planning, monitoring, and evaluating their learning processes—skills that contribute to academic success irrespective of sex. This finding corroborates with Yusuf (2014) [26] and Sani (2015) [21], who found no significant sex differences in academic achievement when learners were taught using student-centered methods. It also aligns with Iserameiya and Uwameiye (2018) [9] who found that metacognitive instruction tends to neutralize gender-based performance disparities by empowering all learners with strategic thinking skills. The study is consistent with Mutua *et al.* (2022) [13] and Dignath and Veenman (2021) [5] respectively who found that metacognitive instruction enhances learning outcomes regardless of learners' sex.

The third finding showed that there was is no significant interaction effect between instructional strategies and sex on students' academic achievement in Physics. This suggests that the effectiveness of instructional strategies such as metacognitive, flipped-classroom, and lecture methods does not differ based on students' sex. In other words, the impact of a given instructional strategy on academic achievement is consistent for both male and female students. This finding is consistent with Ogunleye and Akinola (2018) [18] who reported that while instructional strategies significantly influence achievement in science subjects, sex does not moderate the effectiveness of these strategies. Similarly, Afolabi and Ayeni (2019) [1] found no significant interaction between teaching methods and students' sex on performance in senior secondary school Physics. Ibrahim and Ugwoke (2021) [7] and Omosor and Etinagbedia (2025) [20] in their respective studies confirmed that sex does not significantly alter the effect of instructional approaches on students' learning outcomes in science-based subjects. Their findings suggest that well-structured instructional strategies benefit all students equally, regardless of sex, as long as the strategy is effectively implemented.

Conclusion

Based on the findings of the study, it is concluded that the metacognitive instructional strategy is more effective than the conventional lecture method in enhancing students' academic achievement in Physics. The study further concludes that the effectiveness of the metacognitive instructional strategy is not influenced by students' sex, as both male and female students benefited similarly from its use. Additionally, the absence of a significant interaction effect between instructional strategies and sex indicates that the superiority of the metacognitive instructional strategy over the lecture method is consistent across gender groups. Therefore, the adoption of metacognitive instructional strategies in Physics classrooms can significantly improve students' academic achievement regardless of whether the learners are male or female.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. As the metacognitive instructional strategy proved to be the most effective in enhancing students' academic achievement, it should be prioritized in physics instruction where the goal is to develop students' reasoning, reflection, and problem-solving abilities.
2. Despite no consistent significant differences in

achievement based on sex across the strategies, teachers should ensure inclusive practices that promote equal engagement of male and female students in active learning environments.
3. Curriculum developers and textbook authors should be encouraged by the Ministries of Education to incorporate practical applications of metacognitive strategies into the senior secondary school physics curriculum and instructional resources.
4. Workshops, seminars, and teacher development programs should be regularly organized by educational authorities to build capacity for implementing evidence-based strategies like metacognitive teaching methods.
5. Faculties of education in tertiary institutions should integrate training in these two strategies into pre-service teacher education to ensure future physics teachers are equipped with modern and effective teaching tools.

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