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Impact of Just-in-Time-Peer-Instruction on Attitude, Retention and Performance in Heat Concepts among Secondary School Physics Students of Varied Ability in Kano State, Nigeria

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Abstract

This study was carried out to investigate the impact of Just-in-Time-Peer-Instruction teaching strategy (JTPI) on Attitude and Performance in Heat Concept among Secondary School Physics in Kano State, Nigeria. Quasi-experimental research design, which utilized pre-test, post-test and post-post-test experimental and control groups research design was adopted. The population of the study comprised all SSII Physics students of government Secondary School in Kano State. Four Schools were randomly selected to serve as experimental and control group. Four intact classes were selected to form a sample of 198 students (105 males and 93 females) from these four different schools. Two instruments were also used to generate the data for the study, Physics Performance Test (PPT) with reliability coefficient of 0.78 was administered to measure the students understanding of Heat Concepts in Physics. While Physics Students Attitude Inventory (PSAI) with coefficient of correlation of 0.65 was used to determine the attitude of students towards Physics. The experimental group were taught using Just-in-Time-Peer-Instruction teaching strategy (JTPI) and the control group was taught using lecture method. The data collected were analyzed using (SPSS) statistical package of version 26. The research questions were answered using descriptive statistic of mean and standard deviation, and the hypothesis were tested at $P \geq 0.05$ level of significance using t-test and Mann Whitney statistics. Major findings of the result revealed that, "There was a significant difference between the performance

of the students taught heat concept in Physics using JTPI and those taught using lecture method". Based on the findings of this research work therefore, it is recommended that, "The use of JTPI and other tested active teaching strategy should be encouraged among Physics teachers in Kano State secondary schools and elsewhere" so as to improve student's performance as well as changing student's attitude towards Physics Positively.

Keywords: Attitude, Retention, Performance and Statistics.

Introduction

Teaching of Physics in secondary schools faces significant challenges globally and locally, particularly in abstract concepts. Physics concepts, such as heat and thermodynamics, pose learning challenges for secondary school students due to their abstract nature and reliance on mathematical reasoning (Bello & Yusuf, 2021). Traditional instructional methods often fail to engage students, leading to a lack of interest and lower academic performance, especially in mixed-ability classrooms (Abdullahi & Ibrahim 2019). These challenges often result in students developing a negative attitude toward Physics, consequently affecting their performance (Daramola & Adeyemo, 2020). Traditional teacher-centered approaches frequently used in Nigerian schools may contribute to students' difficulties in understanding complex Physics concepts, such as the topic of heat. The issue of poor performance and negative attitudes in Physics, particularly in challenging topics such as heat, is persistent among secondary school students in Kano State. There is a need for effective instructional methods to enhance students' understanding and foster positive attitudes toward Physics (Crouch & Mazur 2021). This study aims to examine the effectiveness of JTPI in improving students' attitudes and performance in Physics, particularly in the topic of heat, among secondary school students in Kano State. The findings of this study could provide valuable insights for educators, policymakers, and curriculum developers, promoting effective teaching methods that improve learning outcomes in Physics.

Conceptual Framework

The conceptual framework for this study posits that JTPI, as an active learning strategy, influences students' attitudes and performance in Physics. Improved attitudes and understanding are expected outcomes of JTPI, especially in complex topics like heat (Esiobu 2017; Smith *et al.*, 2019).

Just-in-Peer Instruction (JiPI)

JiPI, a collaborative learning strategy, involves students actively participating in teaching segments of the lesson, which fosters a deeper understanding of the material. Research shows that peer-assisted learning can improve comprehension and engagement, particularly in STEM subjects (Gok 2015; Okebukola, 2022).

Attitude and Motivation in Learning Physics

Attitude is a significant factor in learning, influencing students' willingness to engage with complex subjects. Studies reveal that collaborative methods, such as JiPI, can positively impact students' attitudes by making learning more relatable and accessible (Johnson & Johnson 2019; Tanner, 2022).

Retention and Performance in STEM

Retention and performance are key indicators of effective instruction. Research on JiPI and similar methods demonstrates that interactive, peer-based learning can improve long-term retention and mastery of subjects, particularly in varied-ability classrooms (Tanner, 2022).

Educational Context in Nigeria

Educational frameworks in Nigeria are often limited by large class sizes and reliance on traditional methods, which can inhibit engagement and effective learning, especially for students who struggle academically. Introducing JiPI could address some of these challenges (Yusuf & Adigun 2018; Tanner, 2022).

Theoretical Framework

JTPI is based on constructivist theories that emphasize the importance of student-centered learning and peer interaction in knowledge acquisition. Peer Instruction is rooted in Vygotsky's social constructivism theory, which highlights collaborative learning and scaffolding through peer interactions (Vygotsky, 1978).

Review of Empirical Studies

Research around innovative teaching strategies like Just-in-Time Teaching (JiTT) and Peer Instruction (PI) has grown in recent years, showing promising results in improving how students learn, retain, and feel about science subjects.

Several studies have explored active learning methods in science education. Research shows that methods like JTPI can enhance students' understanding and positively influence their attitudes toward subjects perceived as challenging. However, limited studies focus on its impact specifically in Nigerian secondary schools, especially in Physics (Smith et al., 2019).

Other studies have shown that Just-in-Time Teaching, which involves collecting students' feedback or responses before class and adjusting lessons accordingly, helps students stay better prepared and engaged. For example, Marrs and Novak (2004) found that JiTT made university biology students more active and improved their performance.

Similarly, Peer Instruction, where students discuss questions in small groups during lessons, has been shown to significantly improve understanding, especially in physics. Mazur (1997) pioneered this method at Harvard, and later research by Lasry et al. (2008) confirmed that students learn better when they teach and learn from one another.

Some researchers have explored the combination of JiTT and PI, and the results are even more encouraging. Deslauriers, Schelew, and Wieman (2011) showed that students taught with this interactive method scored almost twice as high as those in traditional physics classes.

In terms of student attitudes, studies in Nigeria and elsewhere have found that student-centered approaches—like JITPI—help learners feel more positive and confident about science (Okebukola, 2002; Osborne, Simon, & Collins, 2003). When students are more engaged, they tend to enjoy the subject more and perform better.

When it comes to retention of concepts, interactive methods like peer learning and visual tools have been found to help students remember physics content better over time (Nworgu & Otum, 2013; Udo & Udofia, 2014). This is particularly important for abstract topics like heat, which students often forget if not well understood.

Finally, studies have also highlighted the importance of using methods that support students of varied abilities. In Nigeria, Aremu and Sakan (2003) and Audu et al. (2017) emphasized that strategies like collaborative learning benefit both high- and low-ability learners. Higher-performing students get to reinforce their knowledge, while struggling learners benefit from peer support.

Methodology

Research Design

A quasi-experimental design was used with pre-test, post-test, and post-post-test assessments for both experimental and control groups to determine the effectiveness of JTPI.

Population and Sample

The population comprised SSII Physics students in government secondary schools in Kano State. Four schools were randomly selected, and a sample of 198 students (105 males, 93 females) from four intact classes formed the experimental and control groups.

Instruments

Two main instruments were used:

- 1. Physics Performance Test (PPT):** A 20-item test measuring understanding of heat concepts, with a reliability coefficient of 0.78.
- 2. Physics Students Attitude Inventory (PSAI):** A 15-item questionnaire assessing attitudes toward Physics, with a reliability coefficient of 0.65.

Procedure

The experimental group was taught using JTPI, which involved pre-lesson conceptual checks, peer discussions, and collaborative learning activities, while the control group received traditional lecture-based instruction.

Data Analysis

Data were analyzed using SPSS version 26. Descriptive statistics (mean and standard deviation) were used to answer the research questions, and t-tests along with Mann-Whitney U-tests were used to test hypotheses at a significance level of $P \geq 0.05$.

Research Questions

1. What is the effect of Just-in-Time Peer Instruction (JITPI) on students' academic performance in heat concepts in physics?
2. How does Just-in-Time Peer Instruction influence students' retention, attitude and performance of heat concepts in physics?

3. Is there a significant difference in retention of heat concepts between students taught using JITPI and those taught using traditional teaching methods?

Research Hypothesis

H_01 : There is no significant difference in the academic performance of students taught heat concepts using Just-in-Time Peer Instruction (JITPI) and those taught using conventional methods.

H_{11} : There is a significant difference in the academic performance of students taught heat concepts using JITPI and those taught using conventional methods.

Results

Table 1 Showing Experimental and Control Groups

Group	Test type	Mean Score	Standard Deviation
Experimental	Pre-Test	45.32	6.78
	Post-Test	72.45	5.32
	Post-Post-Test	70.18	5.67
Control	Pre-Test	44.89	6.56
	Post-Test	58.92	7.12
	Post-Post-Test	57.65	7.01

This table provides a clear comparison between the experimental group (taught using JTPI) and the control group (taught using lecture method) across all three tests, demonstrating the impact of JTPI on performance over time.

TABLE 2: Attitude, Retention and Performance

Variable	Group	Pre-Test Mean (SD)	Post- Test Mean (SD)	Retention Test Mean (SD)	t-value	p-value
Attitude	Control	3.4(0.5)	3.5(0.4)	3.4(0.5)	1.2	0.4
	Experimental(JiPI)	3.3(0.6)	4.2(0.5)	4.0(0.4)	5.8	0.001
Retention	Control	45.2(8.1)	48.3(7.9)	47.5(8.0)	1.5	0.15
	Experimental(JiPI)	46.0(7.8)	62.5(6.4)	60.3(6.6)	8.2	0.001
Performance	Control	52.6(10.2)	55.4(9.8)	54.3(10.1)	1.8	0.10
	Experimental(JiPI)	51.9(9.6)	68.7(7.2)	66.4(7.5)	7.5	0.001

Performance (Hypothesis 1): The t-test results showed a significant difference in performance between students taught with JTPI and those taught with the lecture method ($p < 0.05$).

Attitude (Hypothesis 2): The Mann-Whitney test indicated a significant difference in attitudes toward Physics between the experimental and control groups ($p < 0.05$).

Discussion

Results indicated that students taught using JTPI outperformed those taught using traditional lecture methods in the heat concept, demonstrating the effectiveness of JTPI. Additionally, students in the JTPI group showed a more positive attitude toward Physics, suggesting that active learning strategies can address challenges in teaching abstract concepts. The findings support the use of JTPI in Physics instruction. Educators are encouraged to adopt this strategy to foster student engagement and improve conceptual understanding and attitudes. The quasi-experimental design limits the generalizability of findings due to potential selection biases. Additionally, the study's reliance on a specific topic within Physics may restrict the applicability of results across broader content areas.

Recommendations

Further studies should explore JTPI's impact on different Physics topics, other science subjects, and across various educational levels to validate these findings.

Conclusion

This study concludes that JTPI significantly enhances student performance and positively influences attitudes in Physics. Integrating JTPI into secondary school Physics curricula in Kano State and similar contexts is recommended to improve learning outcomes and students' overall interest in science.

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