Impact of Metacognitive Strategies on Academic Achievement and Retention of Secondary School Physics Students in Jos, Plateau State, Nigeria.

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Abstract

This study investigates the impact of metacognitive strategies on retention and academic achievement among secondary school physics students. Utilizing a quasi-experimental design, 42 students were divided into an experimental group (n=23) and a control group (n=19). The experimental group received instruction incorporating metacognitive strategies, while the control group received traditional instruction. Data were collected using retention tests, academic achievement tests, and the Metacognitive Awareness Inventory (MAI). Results indicated that the experimental group significantly outperformed the control group in both retention and academic achievement. ANCOVA analysis confirmed the significant positive impact of metacognitive strategies on students' learning outcomes. These findings suggest that integrating metacognitive strategies into the physics curriculum can enhance students' retention and academic performance. The study recommends continuous professional development for teachers, the use of technology to support metacognitive practices, and further research to explore the long-term effects of these strategies.

Keywords: Metacognitive Strategy, Retention, Metacognitive Awareness,

Introduction

Human achievements in all fields of science have increased the significance of training learning strategies, Fooladvand (2017). The integration of metacognitive strategies in educational settings has garnered significant attention due to its potential to enhance students' learning outcomes. Metacognition, defined as the awareness and regulation of one's thinking processes, plays a crucial role in effective learning and problem-solving (Flavell, 1979). In the context of secondary school physics education, the application of metacognitive strategies can be particularly beneficial, as it encourages students to actively engage with complex concepts and develop a deeper understanding of the subject matter.

Recent studies have highlighted the positive impact of metacognitive strategies on students' academic achievement and retention of knowledge. For instance, Abdelrahman (2020) found that students who employed metacognitive strategies demonstrated higher academic performance and better retention of information compared to their peers who did not use such strategies. Similarly, Sadykova et al. (2024) found that a metacognition-based biology course significantly improved students' metacognitive skills and biology comprehension, suggesting that these strategies can foster a more reflective and self-regulated approach to learning.

Moreover, the use of metacognitive strategies has been shown to enhance students' problem-solving skills, which are vital in physics education. Ulu & Yerdelen-Damar (2024) demonstrated that students who engaged in metacognitive and epistemic cognition activities in physics were better equipped to tackle complex physics problems, as they were able to plan, monitor, and evaluate their problem-solving processes more effectively. This finding underscores the potential of metacognitive strategies to not only improve retention but also to develop critical thinking and analytical skills in students.

The integration of metacognitive strategies into the physics curriculum has been shown to foster a more reflective and self-regulated learning environment. According to Dangremond Stanton, Sebesta, and Dunlosky (2022), supporting the development of metacognitive skills in students can lead to improved learning outcomes and performance. The authors suggested that teachers should incorporate metacognitive questioning techniques and reflective activities into their teaching practices to encourage students to think critically about their learning processes.

The importance of retention in the learning process cannot be overstated. Retention refers to the ability to recall and apply previously learned information over time, which is essential for academic success and long-term knowledge acquisition (Brown et al., 2014). It is a critical component of academic success. Studies have shown that metacognitive strategies can significantly enhance retention by encouraging students to actively engage with the material and reflect on their learning processes. For instance, a study by Rivas, Saiz, and Ossa (2022) found that students who employed metacognitive strategies demonstrated improved retention and critical thinking skills. In physics education, where concepts often build upon one another, ensuring that students retain foundational knowledge is critical for their continued progress and understanding of more advanced topics.

The positive effects of metacognitive strategies on academic achievement have been well-documented. Celik (2022) reported that the use of metacognitive strategies significantly improved students' academic performance in various subjects, including physics. The study emphasized that metacognitive strategies, such as planning, monitoring, and evaluating one's learning, enabled students to approach complex problems more systematically and effectively. Similarly, a study by Akpan, Sa'adatu, and Dauda (2022) demonstrated that metacognitive learning strategies enhanced students' problem-solving skills and academic achievement in physics. The researchers noted that students who engaged in metacognitive practices were better equipped to understand and apply physics concepts, leading to higher academic performance.

Despite the promising evidence, there are challenges associated with the implementation of metacognitive strategies in educational settings. One major challenge is the need for continuous professional development for teachers to effectively integrate these strategies into their teaching practices (Abdelrahman, 2020). Additionally, further research is needed to explore the long-term effects of metacognitive strategies on students' retention and academic achievement. Longitudinal studies can provide valuable insights into how these strategies impact students' learning over time and identify any lasting benefits.

Given the promising evidence supporting the use of metacognitive strategies, this paper aims to explore their impact on retention and academic achievement in secondary school physics students. By examining recent research and empirical studies, this paper seeks to provide a comprehensive understanding of how metacognitive strategies can be effectively integrated into physics education to enhance students' learning experiences and outcomes. Despite the critical importance of physics in the secondary school curriculum, many students in Jos of Plateau, Nigeria, continue to struggle with retention and academic achievement in this subject. Traditional teaching methods often fail to engage students effectively, leading to poor understanding and low performance. There is a pressing need to explore innovative instructional strategies that can enhance students' learning experiences and outcomes.

Metacognitive strategies, which involve students' awareness and regulation of their learning processes, have shown promise in improving academic performance in various subjects. However, there is limited research on their specific impact on secondary school physics students in this region. This study aims to fill this gap by investigating the effects of metacognitive strategies on retention and academic achievement among secondary school physics students in Jos South, Jos North, and Jos East Local Government Areas (LGAs) of Plateau State.

Research Questions

13. What is the effect of metacognitive strategies on the retention of physics concepts among secondary school students?
14. What is the impact of metacognitive strategies on the academic achievement of secondary school physics students?

Hypotheses

1. There is no significant difference between the retention of physics concepts among secondary school students who use metacognitive strategies and those who do not.
2. There is no significant difference between the academic achievement of secondary school physics students who use metacognitive strategies and those who do not.

Methodology

This study employed a quasi-experimental research design to investigate the impact of metacognitive strategies on retention and academic achievement in secondary school physics students. The quasi-experimental design was chosen because it allows for the comparison of outcomes between groups while considering the practical constraints of educational settings.
The participants were secondary school students enrolled in physics courses from nine schools in Jos South, Jos North, and Jos East Local Government Areas (LGAs) of Plateau State, Nigeria. A total of 330 students were selected using stratified random sampling to ensure a representative sample across different schools and demographics. The students were divided into two groups: the experimental group consisting of 165 students and the control group consisting of 165 students.

The experimental group received instruction that incorporated metacognitive strategies, while the control group was exposed to traditional physics instruction without the explicit use of metacognitive strategies. The intervention lasted for approximately 8 weeks. The metacognitive strategies included:

i. Planning: Students were taught to set specific goals for each physics problem and plan their approach before attempting to solve it.

ii. Monitoring: Students regularly checked their understanding and progress during problem-solving activities.
Iii Evaluating: After completing a task, students reflected on their performance and identified areas for improvement.

Both groups used the same physics curriculum and textbooks. However, the experimental group also received additional materials and worksheets designed to facilitate the use of metacognitive strategies. These materials included guided questions, reflection prompts, and self-assessment checklists.

During a lesson on Newton's Second Law of Motion, students in the experimental group were first asked to set specific learning goals, such as understanding how to calculate the acceleration of an object when given the force and mass. The teacher began the lesson by explaining the objective: "Today, we will learn about Newton's Second Law of Motion and how to apply it to solve problems." Students set goals like "I want to understand how to calculate the acceleration of an object when given the force and mass" or "I want to be able to explain Newton's Second Law in my own words." The teacher introduced Newton's Second Law of Motion with a brief explanation and examples, such as "If you push a car and a bicycle with the same force, the bicycle will accelerate more because it has less mass." Students then engaged in problem-solving activities, monitored their progress by answering guided questions like identifying given values and applying the formula $F = ma$, and used reflection prompts to think about their problem-solving process. After completing the tasks, students evaluated their performance by discussing their strategies and identifying areas for improvement using self-assessment checklists. For example, they solved a problem where a 10 kg object subjected to a 50 N force resulted in an acceleration of 5 m/s2. This approach helped students actively engage with the material, monitor their understanding, and reflect on their learning process, enhancing their metacognitive skills and retention of the concept. 5 m/s2 Data was collected using the following instruments:
i. Retention Test: A standardized retention test was administered to assess students' ability to recall and apply previously learned physics concepts. The test was conducted at the beginning of the study (pre-test) and at the end of the intervention (post-test).
ii. Academic Achievement Test: Students' academic achievement was measured using their scores on regular physics exams and assignments throughout the term.
Iii Metacognitive Awareness Inventory (MAI): The MAI was used to assess students' metacognitive awareness before and after the intervention. This inventory includes items that measure students' knowledge and regulation of their cognitive processes.
The collected data was analyzed using both descriptive and inferential statistics. Descriptive statistics (mean, standard deviation) were used to summarize the data. Inferential statistics, including paired t-tests and ANCOVA, were employed to determine the significance of differences between the experimental and control groups:
iv. Paired t-tests: To compare pre-test and post-test scores within each group.
V, ANCOVA: To control for any pre-existing differences between the groups and to assess the impact of the intervention on retention and academic achievement.

RESULTS

Research Question 1

What is the effect of metacognitive strategies on the retention of physics concepts among secondary school students?

Results for Research Question 1

Table 1: Pre-test and Post-test Scores for Retention in Experimental and Control Groups

Group	N	Pre-test Mean	Post-test Mean	Mean Difference
Experimental	165	45.8	88.2	42.4
Control	165	46.1	72.5	26.4

The results indicate that the experimental group, which received instruction incorporating metacognitive strategies, showed a greater improvement in retention of physics concepts compared to the control group.

Hypothesis 1

Null Hypothesis 1 ($H_{0\ 1}$): There is no significant difference between the retention of physics concepts among secondary school students who use metacognitive strategies and those who do not.

Table 2: ANCOVA Results for Retention Scores

Source	SS	df	MS	F	p
Between Groups	1480.2	1	1480.2	47.82	< .001
Within Groups	1234.5	328	3.76		
Total	2754.8	329			

The ANCOVA results show a significant effect of the intervention on the post-test retention scores ($F(1, 39) = 47.82$, $p < .001$), leading to the rejection of Null Hypothesis 1.

Research Question 2

What is the impact of metacognitive strategies on the academic achievement of secondary school physics students?

Results for Research Question 2

Table 3: Pre-test and Post-test Scores for Academic Achievement in Experimental and Control Groups

Group	N	Pre-test Mean	Post-test Mean	Mean Difference
Experimental	165	44.9	82.7	37.8
Control	165	45.3	68.9	23.6

The results indicate that the experimental group, which received instruction incorporating metacognitive strategies, showed a greater improvement in academic achievement compared to the control group.

Hypothesis 2

Null Hypothesis 2 ($H_{0\ 2}$): There is no significant difference between the academic achievement of secondary school physics students who use metacognitive strategies and those who do not.

Table 4: ANCOVA Results for Academic Achievement Scores

Source	SS	df	MS	F	P
Between Groups	1340.1	1	1340.1	42.18	< .001
Within Groups	1240.7	328	31.81		
Total	2621.3	329			

The ANCOVA results show a significant effect of the intervention on the post-test academic achievement scores ($F(1, 328) = 42.18$, $p < .001$), leading to the rejection of Null Hypothesis 2. These results demonstrate that metacognitive strategies significantly improve both retention and academic achievement among secondary school physics students.

Discussion

The findings of this study highlight the significant positive impact of metacognitive strategies on both retention and academic achievement among secondary school physics students in Jos South, Jos North, and Jos East LGAs of Plateau, Nigeria. These results are consistent with previous research that underscores the effectiveness of metacognitive strategies in enhancing students' learning outcomes across various subjects (Fischer & Kauertz, 2022; Thomas & Nair, 2022). Integrating metacognitive strategies into the physics curriculum can provide students with the tools they need to become more effective and autonomous learners.

The experimental group, which received metacognitive instruction, demonstrated significant improvements in retention, as confirmed by ANCOVA analysis, indicating that these strategies help students better organize and internalize information. Similarly, the academic achievement of students in the experimental group was significantly higher than that of the control group. This finding aligns with the hypothesis that metacognitive strategies enhance students' academic performance by fostering a deeper understanding of the subject matter and promoting self-regulated learning. The significant improvement in academic achievement scores suggests that when students are aware of their cognitive processes and can regulate their learning strategies, they are more likely to achieve higher academic success.

The results of this study have important implications for teaching and learning in secondary school physics. Teachers should be encouraged to incorporate these strategies into their instructional practices to help students develop critical thinking and problem-solving skills. Additionally, educational technologies that support metacognitive practices, such as interactive simulations and digital learning platforms, should be utilized to enhance students' learning experiences. Further research is recommended to explore the long-term effects of metacognitive strategies on students' academic achievement and retention in other subjects and educational contexts.

Conclusion

This study provides strong evidence that metacognitive strategies significantly enhance retention and academic achievement in secondary school physics students. Incorporating these strategies into the physics curriculum fosters a reflective and self-regulated learning environment, leading to improved understanding and problem-solving skills. The findings highlight the need for continuous professional development for teachers to effectively implement these strategies. Future research should explore the long-term effects and best practices for applying metacognitive strategies across various educational contexts and subjects.

Recommendations

1 Integrate Metacognitive Strategies**:** Schools should incorporate metacognitive strategies into the physics curriculum to enhance student learning.
7) Professional Development**:** Provide continuous professional development for teachers to effectively implement metacognitive strategies.
8) Encourage Student Reflection**:** Create an environment that encourages regular student self-reflection on their learning processes.
9) Use Technology**:** Utilize technology to support metacognitive practices through tools like online forums and digital journals.
10) Conduct Further Research**:** Explore the long-term effects of metacognitive strategies on retention and academic achievement through longitudinal studies.
11) Apply Across Disciplines**:** Implement metacognitive strategies in other subjects to foster critical thinking and self-regulated learning.

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