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Effect of Problem-Solving Instructional Strategy on Performance in Mathematics among Senior Secondary School Students, Kaduna State, Nigeria

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Abstract
This study investigated the effect of a problem-solving instructional strategy on the mathematics performance of senior secondary school students in Kaduna State, Nigeria. The study was grounded in Constructivist Learning Theory as proposed by Jean Piaget and Lev Vygotsky. A quasi-experimental pre-test, post-test non-equivalent control group design was adopted. The population comprised 42,121 senior secondary school students in public secondary schools in Kaduna State, while a sample of 204 Senior Secondary II (SSII) students was selected using a multi-stage sampling technique. The experimental group was taught mathematics using a structured problem-solving instructional strategy based on Polya's four-step model, whereas the control group received instruction through the conventional lecture method. Data were collected using the Mathematics Performance Test (MPT), which was validated by experts and yielded a Cronbach's alpha reliability coefficient of .918. Descriptive statistics and Analysis of Covariance (ANCOVA) were used to analyse the data at the .05 level of significance. The findings revealed that students exposed to the problem-solving strategy obtained a higher post-test mean score ($M = 74.78$, $SD = 8.59$) than those taught using the conventional method ($M = 65.67$, $SD = 10.15$). However, ANCOVA results indicated that the difference was not statistically significant after controlling for pre-test scores, $F(1, 130) = 0.269$, $p = .605$, $\eta^2 = .002$. Pre-test scores significantly predicted post-test performance, accounting for most of the variance in students' achievement. The study concluded that prior knowledge had a stronger influence on mathematics performance than the instructional strategy employed. It was recommended that mathematics teachers should strengthen students' foundational knowledge and provide sustained exposure to learner-centred instructional approaches such as problem-solving strategies.
Keywords: Problem-solving strategy, Mathematics Performance, Constructivism, Secondary Education, Instructional Methods, Nigeria

Introduction
Mathematics plays a critical role in the education curriculum worldwide, serving as the foundation for scientific, technological, and economic advancements (Agah, 2020; Maass et al.,

2019; Yadav, 2019). Developing logical reasoning, problem-solving, and quantitative literacy is essential for both personal growth and societal progress. In Nigeria, mathematics is considered a core subject at the senior secondary school level. However, students' poor performance in the subject has become a growing concern (Gabriel et al., 2020; Nguyen et al., 2020; Rodríguez et al., 2020). Results from the West African Examinations Council (WAEC) over the past decade highlight a troubling trend of mass failure in mathematics, underscoring the urgency of adopting more effective teaching methods. Contributing factors to these low performance rates include cognitive challenges faced by students and the use of ineffective teaching methods that fail to engage students meaningfully (Federal Ministry of Education, 2020). Identifying the root causes of these issues is essential for developing targeted interventions aimed at improving students' learning outcomes in mathematics (Zakariya & Bamidele, 2016).

In Nigerian classrooms, poor performance is often attributed to the dominance of conventional, teacher-centred instructional methods (Budiningsih et al., 2020; Naing et al., 2019). The conventional lecture method, which focuses on rote memorisation and passive reception of information, remains prevalent. This approach rarely fosters active student participation or encourages critical thinking, creativity, and deep understanding skills essential for success in mathematics (Balarabe et al., 2024; Danlami et al., 2024). As a result, students struggle to apply their knowledge to new problems, leading to surface-level learning and poor examination performance. Research consistently shows that lecture-based methods limit students' opportunities for engagement, collaboration, and deeper exploration of mathematical concepts. Therefore, there is a growing call for a shift toward more student-centered approaches that engage learners actively and promote deeper understanding.

Problem-solving instructional strategies offer a promising alternative by encouraging active learning and critical thinking (Burke & Stewart, 2024; Hutsalo et al., 2024). These strategies allow students to integrate prior knowledge with new experiences, engage with real-world problems, and develop perseverance and self-directed learning habits (Anggraeni et al., 2023; Szabo et al., 2020). Numerous international studies confirm that problem-solving instruction can improve mathematics performance, increase motivation, and foster higher-order thinking skills. However, there is a lack of local empirical research, particularly in Kaduna State, Nigeria, to validate the effectiveness of these strategies in the Nigerian context.

The problem-solving strategy not only promotes critical thinking but also facilitates the integration of previous knowledge with new learning, helping students apply concepts in new situations. This approach encourages students to take ownership of their learning and develop perseverance and self-directed learning habits (Hmelo-Silver, 2004; Hmelo-Silver et al., 2007). While problem-solving has been shown to enhance mathematics performance, motivation, and higher-order thinking globally, there remains limited empirical evidence on its specific effect in Nigeria, especially in Kaduna State. This shows the need for further research to explore the contextual effectiveness of problem-solving instruction in this region.

Problem-solving instructional strategies have long been recognised as essential in moving away from teacher-centred approaches, offering a more dynamic, learner-centred model for mathematics education (Albay, 2020; Intaros et al., 2014). By engaging students in real-world problem-solving, these strategies help them develop critical thinking, integrate previous knowledge with new experiences, and sustain learning across contexts. Additionally, problem-solving fosters a sense of ownership of learning, persistence, and the development of self-directed learning habits (Supriadi & Suherman, 2024). Despite the global success of problem-solving strategy, the local effect in Nigeria, particularly in Kaduna State, remains underexplored, warranting further investigation to validate its effectiveness in the Nigerian educational context.

Statement of the problem

Mathematics is critical for personal development and national progress. However, this importance is undermined by the poor performance of secondary school students in mathematics across Nigeria. In Kaduna State, as in many parts of the country, teacher-centred instructional methods, particularly the lecture method, remain predominant in mathematics classrooms. These methods, characterised by rote memorisation and passive student involvement, limit students' engagement, critical thinking, and application skills, thereby hindering their ability to grasp and apply mathematical concepts effectively. For example, in many classrooms, teachers predominantly deliver content through lectures with minimal student interaction, leaving little room for hands-on problem-solving or collaborative learning. This approach is reflected in the results of recent assessments, where students often struggle with complex mathematical problems and real-world applications.

Kaduna State was chosen as the study site due to its notably lower performance in mathematics compared to other regions in Nigeria. Recent WAEC results show that mathematics performance in public schools in Kaduna State is consistently below the national average, highlighting the need for targeted interventions. The state's diverse demographic and educational landscape, which includes both urban and rural schools, also offers a unique opportunity to explore the effectiveness of problem-solving strategies across different contexts within the same region. Despite the compelling evidence from international studies that problem-solving instructional methods can significantly improve mathematics performance, there is a lack of localised empirical research in Kaduna State. Without evidence from local studies, teachers and policymakers in the region lack concrete guidance on adopting instructional strategies that could address these persistent challenges. This study aims to investigate whether problem-solving instructional strategies significantly improve mathematics performance over conventional lecture methods in Kaduna State. Filling this research gap is crucial for providing a solid foundation for educational reforms in the region. The results could guide future instructional practices, enhance students' performance, and better prepare them to tackle real-world challenges.

Objective of the Study

To determine the effect of the problem-solving instructional strategy on students' performance in mathematics at the senior secondary school level in Kaduna State.

Research Question

1. What is the effect of the problem-solving instructional strategy on students' performance in mathematics at the senior secondary school level in Kaduna State?

Null Hypothesis

H_{01}: There is no significant difference in mathematics performance between students taught using problem-solving strategies and those taught using conventional methods.

Theoretical Framework

The study is grounded in Constructivist Learning Theory, as propounded by Piaget (1972) and Vygotsky (1978). According to constructivism, learners build their understanding and knowledge of the world through active experiences and reflection on those experiences. In a constructivist classroom, students do not simply receive information from an instructor. Instead, they actively engage with content, relate it to their prior knowledge, and apply it to solve relevant real-world problems. This approach emphasises critical thinking, problem-solving, and collaborative learning, which aligns closely with the problem-solving instructional strategy employed in this study (Fosnot, 2013; Schunk, 2012). Piaget's theory of cognitive development suggests that learning occurs when an individual assimilates new experiences into existing cognitive structures and accommodates those structures to integrate new information. In mathematics education, problem-solving strategies offer students the opportunity to engage with tasks that challenge their current understanding, requiring them to select appropriate strategies and refine their knowledge through structured exploration (Piaget, 1972). This fosters the development of higher-order thinking skills, as students encounter and work through novel mathematical challenges (Linn & Hsi, 2000).

Similarly, Vygotsky's Zone of Proximal Development (ZPD) emphasises the importance of social interaction and scaffolding in learning. Vygotsky believed that learners could achieve more advanced cognitive functions with the right support from more knowledgeable others, such as teachers or peers. Problem-solving strategies in this study were operationalised by incorporating cooperative small-group work, peer discussions, and guided discovery. These practices directly align with Vygotsky's framework, as they provide students with opportunities to collaborate, discuss, and receive support in solving problems, thereby enhancing their mathematical reasoning and conceptual understanding (Gauvain, 2001; Vygotsky, 1978).

The problem-solving instructional strategy used in this study was designed to foster active student engagement, collaboration, and reflection, consistent with constructivist principles. Students were encouraged to work in small groups to solve real-world mathematical problems, where they could draw upon their prior knowledge and make connections with new concepts. This approach aligns with Piaget's emphasis on hands-on learning, where students actively construct knowledge through interaction with problems rather than passively receiving information (Piaget, 1972). Additionally, the strategy incorporated Vygotsky's idea of scaffolding, where more knowledgeable peers or instructors guided students through the problem-solving process, offering support when needed but allowing for independent discovery (Vygotsky, 1978). Students' learning was further supported by regular opportunities for peer-to-peer interaction, where they could explain their reasoning and listen to others' perspectives. This collaborative approach not only helped students refine their understanding but also promoted the social aspects of learning, which Vygotsky identified as crucial for cognitive development (Gauvain, 2001). The teacher's role in this environment was more of a facilitator, providing guidance and encouragement as students navigated the problem-solving process, rather than delivering direct instruction in the conventional sense (Fosnot, 2013).

While the constructivist approach provided a solid foundation for this study, there are inherent limitations. One challenge is the variability in students' prior knowledge and cognitive development. Piaget's theory suggests that learners at different developmental stages may require different levels of support, and some students may struggle to grasp complex mathematical concepts without additional scaffolding (Piaget, 1972). In a classroom where students' prior knowledge and abilities vary widely, it may be difficult to ensure that all students are equally supported and engaged (Fosnot, 2013). Another limitation is the time constraints within the school curriculum. Constructivist methods, particularly problem-solving strategies, can be time-consuming, requiring extended periods for exploration and discussion. In a conventional school setting where time is often limited, this can pose a challenge to fully implementing the constructivist approach and may hinder its effectiveness in improving performance within a short timeframe (Schunk, 2012). Lastly, while collaborative learning and peer interaction are valuable components of constructivist teaching, they may not be equally effective for all students. Some students may find it difficult to work collaboratively or may not fully engage in the peer discussions, reducing the overall effect of the strategy (Johnson & Johnson, 2009).

Methodology

The research adopted a quasi-experimental design, employing pre-test and post-test methods with non-equivalent control groups. This design aimed to investigate the effectiveness of problem-solving instructional strategies on students' mathematics performance. The quasi-experimental design involved two groups, a control group and an experimental group, with pre- and post-tests to measure the baseline and post-intervention performance. The control group received instruction using the conventional lecture method, while the experimental group was exposed to problem-solving strategies. The study assessed the change in learning outcomes from pre- to post-test across both groups. The population of the study consisted of 42,121 senior secondary school students from public secondary schools in Kaduna State, Nigeria, as reported by the Kaduna State Ministry of Education (2023). For sampling, 204 students were selected using a multi-stage sampling technique. First, public secondary schools were stratified by senatorial zones to ensure proportional representation. Schools were then randomly selected from each zone. The second stage involved selecting intact classes from senior secondary two (SS2). Two SS2 classes were selected, one serving as the experimental group (receiving the problem-solving strategy) and the other as the control group (using the conventional lecture method). The Mathematics Performance Test (MPT), specifically designed by the researcher, consisted of multiple-choice. The test was both valid and reliable. Content validity was established through expert review by mathematics educators and measurement experts. Reliability was assessed using a pilot study with a separate group of students, yielding a Cronbach's Alpha coefficient of 0.918, indicating high reliability.

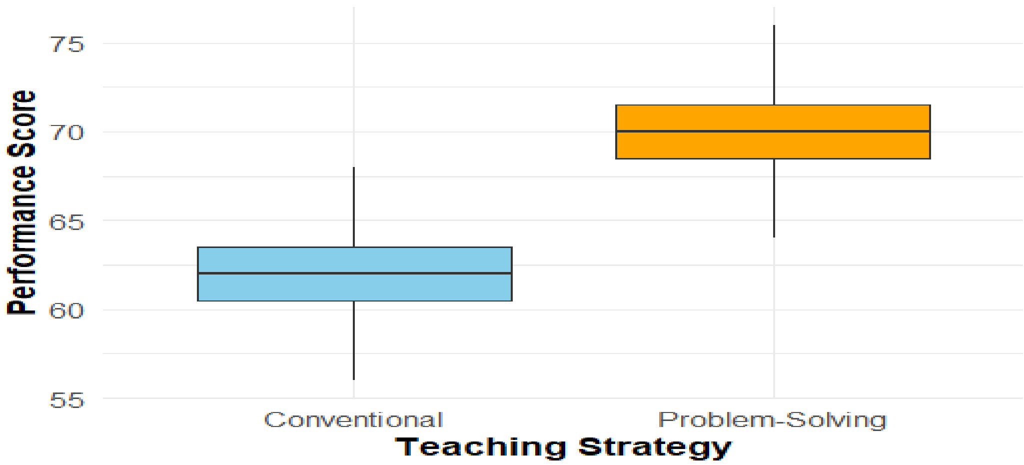
Data collection involved administering a pre-test to both the experimental and control groups to assess baseline mathematics performance. The experimental group received problem-solving instruction based on Polya's four-step model: (1) understanding the problem through group discussions, (2) devising a plan collaboratively, (3) carrying out the plan individually or in pairs, and (4) reflecting on the solution and discussing alternative methods as a class. The teacher acted as a facilitator, promoting deeper thinking through targeted questions. In contrast, the control group received conventional lecture-based instruction, where the teacher explained concepts, and students listened passively. After the intervention, both groups took the same post-test as the pre-test to assess the effect of the instructional method on performance. Data were analyzed using descriptive and inferential statistics. Means and standard deviations are summarized for students' performance before and after the intervention. To test the null hypothesis, Analysis of Covariance (ANCOVA) was used, as it accounts for pre-test deviations and provides a more accurate comparison of post-test performance between the experimental and control groups. The level of significance for analysis was set at 0.05.

Results

The performance of students taught mathematics using the problem-solving strategy was compared to those taught using the conventional method. The descriptive statistics for students' performance scores on the Mathematics Performance Test (MPT) under both teaching methods are presented in Figure 1.1.

Figure 1.1

Box plot of the Mean Performance Score of Conventional and Problem-solving Strategies



The analysis revealed that students taught using the problem-solving strategy had a higher mean score (M = 74.78, SD = 8.59) than those taught using the conventional method (M = 65.67, SD = 10.15). The error bars represent the standard error of the mean, illustrating the variability of the data. The results show that, although students in the problem-solving group had a higher mean score, the variability in performance was slightly lower than that of the conventional group, as indicated by the standard deviations.

Null Hypothesis One

There is no significant difference between the performance of students taught mathematics using a problem-solving strategy and those taught using the conventional method.

To test this hypothesis, a one-way analysis of covariance (ANCOVA) was conducted to examine the effect of the teaching method (Problem-Solving vs. Conventional) on students' mathematics performance while controlling for pre-test scores. The results are presented in Table 1.1.

Table 1.1

Analysis of Covariance (ANCOVA) for Performance by Teaching Method (Problem-Solving vs Conventional)

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13395.534[a]	2	6697.767	844.992	.000	.929
Intercept	734.092	1	734.092	92.613	.000	.416
Pre_Test	10645.896	1	10645.896	1343.088	.000	.912
Group	2.135	1	2.135	.269	.605	.002
Error	1030.436	130	7.926			
Total	665846.000	133				
Corrected Total	14425.970	132				

a. R Squared = .929 (Adjusted R Squared = .927)

The univariate ANCOVA results in Table 1.1 show that the instructional method (Problem-Solving vs. Conventional) did not significantly affect students' performance after controlling for pre-test scores: $F(1, 130) = 0.269$, $p = .605$, $\eta^2 = .002$. The p-value ($p = .605$) is greater than 0.05, indicating insufficient evidence to reject the null hypothesis. This result suggests that the problem-solving strategy did not significantly improve students' performance compared to the conventional method when prior knowledge (pre-test scores) was accounted for. The partial eta squared value ($\eta^2 = .002$) indicates that the effect size of the instructional method on performance was negligible, meaning that the teaching method explained almost none of the variance in post-test scores. The corrected model was significant, $F(2, 130) = 844.992$, $p < .001$, primarily due to the strong influence of pre-test scores on students' performance ($F(1, 130) = 1343.088$, $p < .001$, $\eta^2 = .912$). The R-squared value ($R^2 = .929$, adjusted $R^2 = .927$) suggests that the model explained 92.9% of the variance in post-test scores, with pre-test scores accounting for most of this variance. However, the instructional method did not have a meaningful effect on students' final performance after accounting for prior knowledge. To ensure the validity of the ANCOVA results, Levene's test for equality of error variances was conducted to assess the assumption of homogeneity of variances. The test results were $F(1, 131) = 0.208$, $p = .649$, indicating that the assumption was met. Since the p-value ($p = .649$) is greater than the

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commonly accepted significance level of .05, it can be concluded that the variances in performance scores between the two instructional groups were not significantly different. These findings suggest that, while students in the Problem-Solving group had a higher mean post-test score (M = 74.78, SD = 8.59) compared to the Conventional group (M = 65.67, SD = 10.15), this difference was largely due to pre-existing differences in students' performance, rather than the instructional method itself. The strong influence of pre-test scores indicates that prior knowledge was a significant predictor of post-test performance, overshadowing the effect of the teaching strategy.

Discussion of Results

The results of this study provide important insights into the effect of the problem-solving strategy on students' performance in mathematics. Initially, the descriptive statistics indicated that students taught using the problem-solving strategy had a higher mean performance score (M = 74.78, SD = 8.59) compared to those taught using the conventional method (M = 65.67, SD = 10.15). This difference in mean scores suggested that the problem-solving strategy might have had a positive effect on students' mathematics performance. However, the results of the subsequent analysis using a one-way analysis of covariance (ANCOVA) did not support this preliminary finding. The ANCOVA, which controlled for pre-test scores, revealed no statistically significant difference between the two groups. Specifically, the F-ratio for the effect of the teaching method (problem-solving vs. conventional) was 0.269, with a p-value of 0.605, which is well above the conventional significance level of 0.05. This suggests that after adjusting for the influence of prior knowledge (as measured by the pre-test scores), the teaching method did not have a significant effect on students' post-test performance. The partial eta squared value of 0.002 further supported this conclusion, suggesting that the instructional method explained only a negligible amount of the variance in post-test scores.

A deeper analysis of the ANCOVA model showed that pre-test scores were the dominant predictor of students' post-test performance. The pre-test score explained 91.2% of the variance in post-test scores, as indicated by the F-ratio of 1343.088 and the p-value of less than 0.001. This strong influence of prior knowledge highlights the critical role that students' existing knowledge plays in shaping their academic outcomes (Brod, 2021). The results suggest that the variance in post-test scores was primarily attributable to students' prior knowledge rather than the type of instructional method they received (Ikwuka et al., 2020). Furthermore, to validate the assumptions of the ANCOVA, Levene's test was conducted to check the homogeneity of variances, which revealed no significant differences in the error variances between the two groups ($p = 0.649$). This suggests that the variances in performance scores were similar across both groups, further supporting the ANCOVA analysis (Field, 2024). Despite the higher mean score observed in the problem-solving group, these findings indicate that the instructional method itself did not have a significant effect on students' mathematics performance once prior knowledge was controlled for. The lack of significant effect could be attributed to several potential factors, which should be further explored.

One possible explanation for the negligible effect of the problem-solving strategy is the implementation fidelity. If the strategy was not consistently applied across all classrooms, the intended benefits might not have been fully realized (Bature & Atweh, 2019). Teachers may have varied in how they implemented the problem-solving approach, which could have diluted its effect. Additionally, the duration of the intervention could have played a role; a shorter duration may have been insufficient for students to fully engage with and internalise the problem-solving strategy. The effectiveness of such strategies may require more time to develop fully. Moreover, students' readiness for such an approach could have influenced its effectiveness. If students were not familiar with problem-solving techniques or lacked the necessary foundational skills, they may have struggled to benefit from this instructional method (Nilimaa, 2023). In comparing these findings to similar studies conducted in different contexts, it is important to note that some studies in more resource-rich or structured environments have reported more pronounced effects of problem-solving strategies. Cultural and regional differences may also influence the outcomes. For instance, in settings where problem-solving strategies are more frequently used, students might be more accustomed to these methods, leading to better results. In contrast, students in contexts with limited exposure to such strategies may require more time to adapt, which could explain the lack of significant effect in this study. The findings also have significant practical implications for teachers and policymakers. For educators, these results suggest that while problem-solving strategies have potential benefits, they may need to be implemented alongside efforts to strengthen foundational skills in mathematics. Policymakers should ensure that teachers receive adequate training on how to effectively implement problem-solving approaches and that the curriculum is designed to support a gradual transition to these innovative strategies. Additionally, interventions should be of sufficient duration to allow students to adjust to and benefit from the new teaching methods.

Conclusion

This study concluded that the use of the problem-solving instructional strategy resulted in higher mean performance scores in mathematics among senior secondary school students in Kaduna State when compared with the conventional lecture method. However, the difference in students' performance was not statistically significant after controlling for pre-test scores. The findings therefore indicate that the instructional strategy alone was not a major determinant of students' achievement in mathematics. Rather, students' prior knowledge and existing academic background had a stronger influence on their post-test performance. The study further revealed that although problem-solving strategies have the potential to enhance active participation, critical thinking, and collaborative learning, their effectiveness may depend on factors such as students' readiness, teachers' implementation skills, duration of exposure, and the educational context in which the strategy is applied. The discussion showed that variations in classroom implementation, limited exposure to learner-centred methods, and inadequate foundational mathematical knowledge may have reduced the overall impact of the strategy in Kaduna State secondary schools. Based on these findings, the study concludes that improving students' foundational understanding of mathematics is essential for achieving better learning outcomes, regardless of the instructional strategy adopted. It also concludes that problem-solving instructional strategies should not be viewed as a standalone solution to poor mathematics performance but should be implemented alongside adequate teacher preparation, continuous practice, and supportive learning environments that encourage active student engagement.

Recommendations

Based on the findings and their broader implications, the following recommendations are made:

1. Mathematics teachers should strengthen students' foundational knowledge and prior understanding of mathematical concepts through regular assessments and remedial support, since prior knowledge was found to have a stronger influence on students' performance than the instructional strategy employed.
2. Teachers should consistently and effectively implement problem-solving instructional strategies alongside conventional teaching methods to promote active participation, critical thinking, and gradual adaptation to learner-centred approaches in mathematics classrooms.
3. Educational stakeholders and researchers should support continuous teacher training and conduct further long-term studies on problem-solving instructional strategies to

determine how sustained implementation can improve students' mathematics performance in different educational contexts.

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demic outcome

Introduction

The development and use of strategies for effective teaching and learning to improve learners' academic outcome has often occupied the minds of science educators. When it comes to how best to learn for effective academic achievement, metacognition should not be overlooked. Moreover, the importance of metacognition is echoed in its study in the domain of artificial intelligence (AI) and modelling. It is a construct that has attracted the attention of the psychologists for decades now. According to Flavell (1979), who is typically known as the founding father of metacognition, metacognition is "knowledge and cognition about cognitive phenomena". It is often quoted in literature as "thinking about one`s thinking or"cognition about cognitions" (Flavell, 1999; Bogdan, 2000). In its original conceptualization, metacognition refers to the learner's knowledge about his cognitive activities and the regulations of these activities in the learning process. Metacognition was later modified to mean learner`s awareness of his skills, strategies and resources that he needs in order to carry out his learning task effectively and his ability to deploy self-regulatory mechanism to successfully complete the task (Noushad, 2008).

In plain language, metacognition is all about the learner's self-knowledge/ stored knowledge or beliefs or self-awareness of how he learns/thinks he learns and the approaches he uses to process information in the learning process; his feelings of how well or badly he learns often challenges and ushers him into recognizing and developing alternative skills /abilities or strategies to redirect and monitor his learning progress for better results.

Over the years, metacognition has been implicated in helping learners to monitor and manage their cognitive functions (Young & Fry, 2008); monitor and have oversight function of their thoughts (Shehzad, 2012); develop strategies or learning approaches (Narang & Saini, 2013); select the most appropriate learning/cognitive strategies for achievement of their personal goals (Abdelrahman, 2020); prepare for future actions, evaluate their learning, memorization and readiness for examinations (Shea, 2019); improve on their academic performance (Sword, 2021 & Joseph, 2023); take control of their learning process (Ozcakmak *et al*, 2021); and learn independently, persevere to do better, grow socially and emotionally and transfer knowledge and understanding gained in one situation to another task (Sword, 2021).

Above all, metacognition gives an insight into how learners learn; provides an opportunity for optimal teaching and learning for greater efficiency (Joseph, 2023).

From the foregoing, it can be deduced that metacognition is a powerful predictor of learning or academic outcome and therefore deserves investigation.

It is worth noting that metacognitive components have been identified and studied by many researchers (Mwangi *et al*, 2024; Ajaja & Eravwoke, 2017; Bidjerano, 2005). These components include metacognitive knowledge (i.e. the learners' awareness of how they learn and the various approaches they use to process their information; metacognitive experience which is about reflection on the learning for feedback to regulate their learning; metacognitive thoughts which involve the learners` designing strategies to overcome barriers/challenges to their learning in order to succeed. Although significant improvement on academic performance of students has been reported about the deployment of metacognition to learning (Young & Fry, 2008; Narang & Saini, 2013; Abdelrahman, 2020; Stanton *et al*, 2021; Sword, 2021; Joseph, 2023; Mwangi *et al*, 2024), reports regarding the differences between gender and metacognition remained inconclusive. For instance, Akin (2016), using secondary school students as his subjects in the country of Turkey noted that girls have higher metacognitive skills than boys in listening and understanding. Also, Bidjerano (2005) noted a higher metacognitive awareness level of females than the males among 198 university undergraduates of Northeastern USA offering basic education courses. In an Indian University of Tezpur, Pradhan & Das (2021) noted that metacognitive ability could account for about 43% of academic performance of undergraduate students of humanity, social sciences, school of engineering and school of sciences without mention of gender. Lavinia and Ciascai, (2011) in Rumania, working with primary school pupils noted than female pupils have greater metacognitive skills that their male counterparts. In Nigeria, Odofin *et al*, (2024) showed that females who utilized appropriate metacognitive reading strategies outperformed their male counterparts in reading ability in secondary schools. However, Popoola *et al*, (2021), still in Nigeria noticed no significant influence of metacognition of students` gender on performance in mathematics among secondary school students.

Similarly, studies conducted with primary school pupils in Thai by Chantharanuwong *et al*, (2012) and the one carried out by Duvan *et al*, (2020) in Columbia with secondary school students showed no significant difference in metacognitive skills between the female the male respondents.

Statement of the Problem

From available literature reviewed, there seems to be no studies on metacognition in the Nigerian setting involving university students especially regarding science education students- most studies on metacognition have been on the foreign scene. For instance, Bidjerano (2005) worked on undergraduate students that offered basic education courses in Northeastern USA. Abdelrahman (2020) studied the undergraduate sociology students of Ajman University in the United Arab Emirates while Pradhan and Das (2021) dwelt on undergraduate students of humanity, social sciences, school of engineering and school of sciences in Tezpur University of India. Also, Mir and Peerzada (2022) in India performed their study among college students of Kashmir. It is therefore necessary to investigate in the situation in the Nigerian university setting. Moreover, as findings of studies on metacognition and gender are unsettled and contradictory, this study seeks to make its contribution.

Objectives of the Study

The study sought to accomplish the following two objectives:

i. Investigate the metacognitive ability of male and female chemistry education students of Kaduna State University, Kaduna.

ii. Determine the impact of the metacognitive ability of the students` gender on their academic performance inchemistry.

Research Questions

The following research questions were stated for the study:

i. Does the metacognitive ability of the male chemistry education students of Kaduna state University differ from that of their female counterparts?

ii. How does the metacognitive ability of the students` gender impact on their academic performance in chemistry?

Hypotheses for the Study

The following corresponding null hypotheses were framed for the study:

Ho^1: There is no significant difference between the metacognitive ability of the male and female chemistry education students of Kaduna State University.

Ho^2: There is no significant impact of the metacognitive ability of the students` gender on their academic performance in chemistry.

Methodology

The study was designed to describe the differences or otherwise in metacognitive ability of male and female students and its influence on the students` academic performance in chemistry.Since the description of the situation was desired and questionnaires were used to gather information, the survey research design was considered appropriate for the study.A total of seventy-five 200L first degree chemistry education students (20 males of 55 females) of 2023/24 academic session drawn randomly from a population of 150 students (50 males and 100 females) in the University constituted the sample size for this study. The Metacognition Assessment Scale (MAS) of Joseph (2023) in its questionnaire format was adopted for the study. MAS, as reported by the designer, had its face validity established by experts` judgment and its content and construct validity settled by factorial analysis. Its reliability value was .73 by Cronbach`s Alpha index. It has 13 valid items designed to measure 5 different components of metacognition using the four-point Likert Scale of Strongly Agreed (4), Agreed (3), Disagreed (2), & Strongly Disagreed (1). 75 copies of this instrument were administered to the respondents during a normal class session and were successfully retrieved, marked and recorded. All the data collected from the students using the five metacognitive components of the scale, namely, cognitive knowledge, procedural knowledge, evaluation, cognitive monitoring and information management strategies were pulled together and judged as a reflection of students' metacognitive ability in this study. Also, scores from moderated Chemistry Achievement Test (CAT) on a chemistry course titled introductory organic chemistry (CHM204) administered to these same students were extracted and used as a measure of their performance (academic outcome). CAT was designed by the researchers and had14 multiple choice questions of 1mark each; 5 fill-in-the blank questions of 2marks each and one essay question(subdivided into sections a-e) of 16marks, giving a grand total of 40marks. Its validity was ascertained by four experts in the subject while its reliability by test-retest method on a sample of the same level of students in another university gave an index of .70 by Pearson's Product Moment reliability formula. These two instruments were, therefore, judged adequate for gathering data for the study. The data obtained for the study were processed using SPSS version 26 and the results are presented in Tables 1- 4:

Table 1: Difference in metacognitive ability between male and female chemistry education students

Gender& Metacognition	N	X	SD	Standard Error
Male	20	3.25	0.49	0.11
Female	55	3.33	0.35	0.05

Table 1 shows that the metacognitive ability of the female students is slightly higher than that of the male students by a mean difference of 0.08.

Table 2: Difference in impact of metacognitive ability of gender on academic outcome

Gender& Performance	N	X	SD	Standard Error
Male	20	13.62	3.90	0.87
Female	55	12.54	3.46	0.47

In terms of performance, Table 2 shows that the male students had a higher mean score of 13.62 while their female counterparts recorded the mean performance score of 12.54, the difference between both sexes being 1.08.

To test the level of significance of the differences in metacognitive ability in gender and performance of both sexes, t-test was applied at 0.05 confidence level and the results are as shown in Tables 3 and 4 respectively.

Table 3: t-test comparison of metacognitive ability difference between male and female chemistry education students

Gender& Metacognition	N	X	SD	Standard Error	df	t-value	P
Male	20	3.25	0.49	0.11	73	.81(NS)	0.42
Female	55	3.33	0.35	0.05			

NS= Not significant, $P > 0.05$; t-critical = 1.98

There is statistically no significant difference between the metacognitive ability of the male and female chemistry education students, $P=0.42 > 0.05$ at $df = 73$; $t = .81 < 1.98$.

Table 4: t-test comparison of impact of metacognitive ability of gender on academic outcome

Gender& Performance	N	X	SD	Standard Error	df	t-value	P
Male	20	13.63	3.90	0.87	73	1.17(NS)	0.25
Female	55	12.54	3.46	0.47			

NS= Not significant, P > 0.05, t critical = 1.98

There is statistically, no significant difference of the impact of metacognitive ability of students` gender on their academic (outcome) performance, p = 0.25 > 0.05 at df 73; t = 1.17 < 1.98

Discussion

The results of this study reveal that the female undergraduate chemistry education students of the university recorded higher metacognitive ability than their male counterparts (Table1). But in terms of academic outcome, the opposite was observed: the male undergraduates outperformed their female counterparts (Table2). However, these gender differences noted in metacognition and academic performance (outcome) are not statistically significant (Tables3&4: P-metacognition = 0.42>0.05; P-academic performance = 1.17 > 0.05). The findings of this study tend to corroborate the findings of studies by Mir and Peerzada (2022) about college students in Kashmir, India; and Chantharanuwong *et al* (2012) in Thai about primary school pupils; Duvan et al (2020) in Columbia and Popoola (2021) about secondary school studentsin Nigeria.

With particular reference to university setting, the findings of this study deviate from those of Bidjerano(2005) and Abdelrahman(2020) who noticed a significantly higher metacognitive ability in females than in males with a corresponding higher academic performance of the former than the latter. The findings of these authors lend credence to the findings of Lavina and Ciascai (2011) about primary pupils; Akin (2016) and Odofin *et al* (2024) about secondary school students, although Mwangi in a Kenyan setting found the opposite about secondary school students. Pradhan and Das (2021) had also reported in their study that metacognition accounted for 43% of variability of academic achievement of undergraduate students thus portraying that metacognition in still a powerful predictor of academic success.

The non-significant difference in metacognition and academic performance of the gender in the present study can be explained simply by reasoning that the students do not seem to have well developed metacognitive strategies to help them cope with their academic tasks. This might as well explain the findings of studies of Chantharanuwong et al (2012), Duvan et al (2020), Popoola(2021) and Mir and Peerzada(2022).This is reflected in their overall performance in the CAT administered to them. Out of the total raw score of 40marks for the test with 20marks as half of the score, the mean score for the entire test for 75 students was 12.88 with a standard deviation of 3.51. Therefore, for a raw score of 19marks, the standard score (Z) can be predicted to be 1.74 implying that 95.91% of the students (i.e. 72 students) scored below 19 while only 4.09% (only 3 students) scored above 19. This is an indication of poor academic outcome or performance.

Conclusion and Recommendations

The main thrust of this study was to investigate the gender differences in metacognitive ability and academic outcome/ performance of chemistry education students of Kaduna State University. Findings of this study show that the female students have higher metacognition than their male counterparts. But on the basis of academic outcome, the male students outperformed their female folks. However, these differences were found to be statistically not significant.

In line with the findings of this study, it is recommended that:

i. Metacognition and its various strategies for learning should be introduced to students and properly taught, preferably, in a general study course to show its relation and application to effective learning.

ii. A workshop on metacognition and its strategies should be organised for science (chemistry) teachers so to enable them bring the knowledge acquired periodically into the teaching-learning situations to aid students learn effectively.

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