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Guided Discovery and Students' Attitudes toward Mathematics: Evidence from a Quasi-Experimental Study in Nigerian Secondary Schools

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Abstract

Students' attitudes toward mathematics remain a persistent concern in mathematics education, particularly in contexts where teacher-centred instructional practices dominate. This study examined the effect of Guided Discovery Strategy (GDS) on students' attitudes toward mathematics in Nigerian secondary schools. A nonrandomized control group pretest–posttest quasi-experimental design was employed. The population comprised Senior Secondary II students in public schools in Kaduna State, from which a sample of 142 students was selected using a multi-stage sampling technique and assigned to experimental (n = 72) and control (n = 70) groups. Data were collected using an adapted 19-item Mathematics Attitude Questionnaire (MAQ) whose psychometric structure was examined through confirmatory factor analysis, which demonstrated acceptable internal consistency (coefficient omega = .787). Data were analysed using Analysis of Covariance (ANCOVA) at the 0.05 level of significance. Results showed that students exposed to GDS had higher mean attitude scores (M = 67.61, SD = 7.99) than those taught using conventional lecture method (M = 60.80, SD = 7.64). However, the difference was not statistically significant, $F(1, 139) = 3.813$, $p = .053$, partial $\eta^2 = .027$. The findings indicate that short-term implementation of GDS may not significantly influence students' attitudes, suggesting the need for sustained and context-sensitive instructional approaches in mathematics education.

Keywords: guided discovery strategy, students' attitudes, mathematics education, secondary school students, instructional methods

1 Introduction

Mathematics is widely recognized as a foundational discipline that underpins scientific development, technological advancement and logical reasoning (Organisation for Economic Co-operation and Development, 2022). Its applications extend across diverse fields such as engineering, economics, computer science, medicine and data science, making it indispensable for both individual career development and national socioeconomic growth (Akinoso, 2024). In contemporary societies, mathematical literacy is increasingly viewed as a critical competency required for participation in a knowledge-driven economy (Rakesh, 2023). Despite this centrality, a persistent challenge exists in many educational contexts, particularly in developing countries, where students continue to exhibit negative perceptions and weak engagement with mathematics. Many learners describe the subject as abstract, difficult and emotionally demanding, which contributes to avoidance behaviours and low achievement. This situation presents a paradox: while the demand for mathematical competence continues to increase globally, students' interest and positive disposition toward the subject appear to be declining. Research evidence further shows that students' attitudes significantly influence their motivation, classroom engagement, persistence in problem-solving and overall academic achievement (Mashwama et al., 2025; Mazana et al., 2019; Schoenfeld & Sloane, 2016). Consequently, improving students' attitudes toward mathematics has become a critical priority in mathematics education research and instructional practice.

However, mathematics education research has historically placed greater emphasis on cognitive outcomes such as academic achievement, procedural fluency and problem-solving proficiency, often at the expense of affective variables (Al-Mutawah et al., 2019). While cognitive outcomes remain essential indicators of learning, they do not fully capture the complexity of students' learning experiences. Increasing evidence suggests that affective factors such as beliefs, emotions, self-efficacy and attitudes play a crucial role in shaping students' engagement with mathematical tasks and problem-solving activities (Wen & Dubé, 2022; Zakariya, 2022). Negative attitudes, mathematics anxiety and low self-efficacy have been consistently identified as major barriers to effective learning, often resulting in avoidance, disengagement and poor performance (Hussein & Csíkos, 2023; Li et al., 2021; Zhang & Wang, 2020). In some cases, even when instructional methods are pedagogically sound, students may still perform poorly due to emotional and psychological resistance toward the subject. This implies that instructional effectiveness cannot be fully achieved by focusing solely on content delivery and cognitive mastery without addressing the affective dimension of learning, which shapes students' willingness to participate and persist in mathematical tasks.

In response to the limitations of traditional teacher-centred instructional approaches, contemporary mathematics education has increasingly emphasized student-centred pedagogies, among which Guided Discovery Strategy (GDS) has gained considerable attention. GDS is an instructional approach that encourages learners to actively construct mathematical knowledge through guided exploration, questioning, problem-solving and teacher-facilitated discovery. Rather than directly transmitting information, the teacher structures learning experiences in a way that allows students to identify patterns, formulate relationships and derive mathematical concepts independently. This process is intended to promote deeper conceptual understanding as well as positive affective outcomes, including increased interest, curiosity, confidence and engagement in learning activities (Kasmiana et al., 2020). Empirical studies have also shown that student-centred approaches can enhance classroom participation and intrinsic motivation (Glavind et al., 2023; Nwobodo-Anyadiegwu & Okanya, 2026). Furthermore, discovery-oriented learning environments have been associated with reductions in mathematics anxiety and improvements in self-efficacy, suggesting their potential to influence both cognitive and affective domains of learning (David, 2019; Ndaba, 2021). These findings have strengthened the assumption that Guided Discovery Strategy may serve as an effective alternative to conventional lecture method in improving students' learning experiences in mathematics.

Despite the growing body of literature supporting student-centred instructional approaches, empirical evidence regarding the specific impact of Guided Discovery Strategy (GDS) on students' attitudes toward mathematics remains limited and inconsistent. Existing Nigerian studies on guided discovery have predominantly examined cognitive outcomes such as academic achievement, conceptual understanding and science process skills (Abari & Ikyule, 2021; Asanre et al., 2022; Gbadamosi et al., 2024; Inyang et al., 2023; Mgbomo et al., 2024; Namani & Yusuf, 2025). Other studies have considered affective outcomes such as interest and attitude, but the available evidence remains limited and contextually varied (Danlami, 2025; Ndaba, 2021; Yusuf, 2020). Consequently, there is insufficient empirical evidence on whether Guided Discovery Strategy produces statistically significant changes in students' overall attitudes toward mathematics among public secondary school students in Kaduna State, Nigeria. The present study addresses this specific gap by comparing students' post-intervention attitudes under Guided Discovery Strategy and conventional lecture method while controlling for baseline attitude differences through ANCOVA. Moreover, evidence from Kaduna State remains limited, particularly regarding students' attitudes toward mathematics in public secondary schools. The selected educational zones Lere, Sabon Tasha and Zonkwa provide distinct school-based contexts in which the strategy can be examined among Senior Secondary II students under comparable public-school conditions. Investigating these zones therefore provides context-specific evidence on whether Guided Discovery Strategy can influence students' attitudes toward mathematics within Kaduna State. This study addresses this gap by empirically examining the effect of Guided Discovery Strategy on students' attitudes toward mathematics in secondary schools in Kaduna State, Nigeria. Specifically, the study compares the attitudes of students taught using Guided Discovery Strategy with those taught using conventional lecture method within a quasi-experimental framework. The study is guided by the research question: What is the difference in the attitudes toward mathematics between students taught using Guided Discovery Strategy and those taught using conventional lecture method?

***H_{01}**: There is no significant difference in the attitudes toward mathematics of students taught using Guided Discovery Strategy and those taught using conventional lecture method.*

By focusing on the affective domain of learning, this study contributes to a more holistic understanding of instructional effectiveness in mathematics education. It also provides empirical evidence on whether instructional strategies that promote active learning can meaningfully influence students' attitudes, thereby informing pedagogical practice and curriculum development. Ultimately, the study underscores the importance of integrating both cognitive and affective dimensions in mathematics instruction to improve overall learning outcomes.

2 Literature Review/Theoretical Framework

Understanding students' attitudes toward mathematics has become a central concern in mathematics education research due to its significant influence on learning outcomes, motivation and classroom engagement (Lotey et al., 2026). Attitude toward mathematics is generally conceptualized as a multidimensional construct that includes students' cognitive beliefs about mathematics, their emotional responses to mathematical tasks and their behavioural tendencies such as persistence, avoidance or engagement. Empirical evidence consistently demonstrates that students with positive attitudes toward mathematics are more likely to achieve higher academic performance, demonstrate persistence in problem-solving and show greater willingness to engage with challenging tasks (Omoladun et al., 2026; Zakariya et al., 2026). Conversely, students with negative attitudes often experience mathematics anxiety, reduced confidence, avoidance behavioursand persistent underachievement (Hussein & Csíkos, 2023; Li et al., 2021; Zhang & Wang, 2020). Despite the well-established link between attitude and achievement, much of the literature in mathematics education has traditionally prioritised cognitive outcomes, such as achievement and procedural fluency, while paying comparatively less attention to affective variables. This imbalance has contributed to a limited understanding of how instructional practices influence students' emotional and motivational orientations toward mathematics learning.

In response to this gap, student-centred instructional approaches such as Guided Discovery Strategy (GDS) have gained increased attention in mathematics education research. GDS is an instructional approach that promotes active learner participation through structured exploration, guided questioning and problem-solving activities, allowing students to construct mathematical knowledge rather than passively receiving it (Abari & Ikyule, 2021; Danlami, 2025; Kadir et al., 2023). Within this approach, the teacher acts as a facilitator who provides scaffolding and direction while encouraging learners to discover patterns, relationships and mathematical principles independently. Empirical studies suggest that such learner-centred environments can enhance conceptual understanding, engagement and participation in classroom activities (Kasmiana et al., 2020). Furthermore, some research has reported that discovery-oriented learning may positively influence affective outcomes, including increased interest in mathematics, reduced anxiety levels and improved confidence in handling mathematical tasks (David, 2019; Ndaba, 2021). However, despite these reported benefits, findings across studies remain inconsistent, particularly regarding whether these approaches produce sustained improvements in students' attitudes toward mathematics over time.

This inconsistency in empirical findings has generated an important debate in the literature concerning whether increased student participation in learning activities necessarily translates into improved attitudes toward mathematics. While some scholars argue that active learning environments naturally foster positive emotional and motivational outcomes by promoting autonomy, engagement and ownership of learning, others caution that discovery-based approaches may place excessive cognitive demands on learners if not properly scaffolded. According to this view, insufficient instructional guidance may lead to cognitive overload, confusion and frustration, which can ultimately reinforce negative attitudes rather than improve them(Chew & Cerbin, 2021; Kirschner et al., 2025). This suggests that the effectiveness of Guided Discovery Strategy is not uniform but may depend on several contextual and pedagogical factors, including the quality of instructional delivery, teacher competence, learners' prior knowledge and existing attitudes toward mathematics. As a result, the relationship between instructional strategy and students' attitudes is complex and mediated by both cognitive and affective processes operating within the learning environment.

The present study is anchored on Constructivist Learning Theory and Expectancy–Value Theory, which together provide a comprehensive framework for explaining how instructional strategies influence students' attitudes toward mathematics. Constructivist Learning Theory posits that learners actively construct knowledge through interaction with their environment, experiences and social context, rather than passively receiving information (Piaget, 1972; Vygotsky, 1978). From this perspective, Guided Discovery Strategy aligns with the principles of active engagement, exploration, scaffolding and social interaction, where the teacher facilitates learning by guiding students toward the discovery of mathematical concepts (Bruner, 1961; Janson et al., 2020). This active involvement is expected to promote deeper understanding and foster positive affective responses such as interest, curiosity and confidence. However, constructivist theory also acknowledges that learning may be hindered when learners receive inadequate support, which may lead to confusion and negative emotional reactions. Complementing this perspective, Expectancy–Value Theory explains motivation and attitude formation based on students' expectations of success and the subjective value they attach to learning tasks (Eccles & Wigfield, 2002, 2024). Instructional strategies such as GDS may enhance expectancy by improving understanding and increase task value by making learning more meaningful and relevant. However, if learners continue to experience difficulty or fail to perceive relevance, their expectancy and value beliefs may weaken, thereby limiting positive attitudinal change.

The integration of Constructivist Learning Theory and Expectancy–Value Theory provides a strong explanatory basis for understanding how Guided Discovery Strategy may influence students' attitudes toward mathematics. Specifically, GDS is expected to enhance cognitive engagement through active learning while simultaneously increasing students perceived value and confidence in mathematics learning. However, this theoretical framework also recognises that such outcomes are not automatic or guaranteed, particularly in contexts where students already hold entrenched negative beliefs about mathematics or where instructional interventions are of short duration. Despite increasing interest in student-centred instructional approaches, there remains limited and inconsistent empirical evidence regarding their effectiveness in improving students' attitudes toward mathematics, especially within Nigerian secondary school contexts. This study therefore addresses this gap by empirically examining whether Guided Discovery Strategy produces significant differences in students' attitudes toward mathematics compared to conventional lecture method methods. Grounded in the integrated theoretical framework, the study is guided by the following null hypothesis:

3 Materials and Methods

3.1 Research Design

This study adopted a nonrandomized control group pretest–posttest quasi-experimental design. The design was considered appropriate because the study was conducted in a natural school setting where intact classes were used, making random assignment of individual students impractical. The design enabled comparison between an experimental group and a control group while controlling baseline differences using pretest measures. The experimental group was taught using the Guided Discovery Strategy (GDS), while the control group received conventional lecture method. Both groups were assessed before and after the intervention to determine changes in students' attitudes toward mathematics.

3.2 Study Area and Participants

The study was conducted among Senior Secondary School II (SS2) students in public secondary schools in Kaduna State, Nigeria, specifically within Lere, Sabon Tasha and Zonkwa educational zones. These zones were selected due to their accessibility and comparable school characteristics, including staffing and instructional resources. The population comprised approximately 42,121 SS2 students. This group was considered appropriate because students at this level have sufficient exposure to mathematics and have developed relatively stable, yet modifiable, attitudes toward the subject.

3.3 Sample and Sampling Technique

A multi-stage sampling procedure was employed in selecting the participants for the study. First, two public secondary schools were purposively selected based on similarities in school characteristics, including school type, availability of qualified Mathematics teachers and comparable academic and infrastructural conditions. Second, one intact SS II class was randomly selected from each of the sampled schools. The use of intact classes was considered appropriate because it preserved the natural classroom structure, minimized disruption to regular school activities and facilitated the implementation of the instructional treatment.

The selected intact classes comprised a total of 142 SS II students, consisting of 72 students in the experimental group and 70 students in the control group. The sample frame showing the distribution of students in experimental and control groups is presented in Table 1.

Table **1**

Sample Frame Showing the Distribution of Students in the Experimental and Control Groups

Sampled School	Group	Number of Students (n)
School A	Experimental Group	72
School B	Control Group	70
Total		142

The sample size of 142 students was considered adequate for the application of inferential statistical techniques, particularly Analysis of Covariance (ANCOVA), which was used to determine the effect of the instructional treatment while controlling for possible initial differences in students' pretest scores. The use of intact classes also helped to maintain the existing classroom structure and minimize disruption to normal school activities during the intervention.

3.4 Instrumentation

Data were collected using the Mathematics Attitude Questionnaire (MAQ), adapted from the attitude measurement instrument developed by Palacios et al. (2013). The questionnaire was adapted to suit the Nigerian secondary school context by modifying the wording of selected items to enhance clarity and contextual appropriateness. The final instrument comprised 19 items measured on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Negatively worded items were reverse-scored before computing the attitude scores so that higher scores consistently represented more favourable attitudes toward mathematics. The psychometric structure of the adapted MAQ was examined using confirmatory factor analysis, resulting in a two-factor structure comprising Perception of Incompetence and Enjoyment of Mathematics. The Perception of Incompetence dimension comprised items MAQ01–MAQ06 and MAQ09–MAQ12, while the Enjoyment of Mathematics dimension comprised items MAQ13–MAQ21. The overall 19-item MAQ demonstrated acceptable internal consistency (coefficient omega = .787), while the Perception of Incompetence and Enjoyment of Mathematics subscales demonstrated high internal consistency, with coefficient omega values of .933 and .872, respectively. The instrument was also subjected to expert review to establish content validity, with experts in mathematics education and measurement and evaluation examining the items for relevance, clarity and contextual appropriateness.

3.5 Intervention Procedure

The experimental group received instruction using the Guided Discovery Strategy, which emphasized active participation, guided exploration and problem-solving. Instruction followed three stages: (i) presentation of contextual problems to stimulate thinking, (ii) guided exploration and discussion with teacher facilitation and (iii) reflection and consolidation of discovered concepts. The control group was taught using the conventional lecture method involving direct explanation and individual practice. Both groups covered the same instructional content over the same period to ensure compatibility.

3.6 Data Collection Procedure

Data collection was conducted over six weeks. In the first week, the MAQ was administered as a pretest to both groups to establish baseline attitudes. The intervention was then implemented for the experimental group, while the control group continued with conventional lecture method. At the end of the intervention period, the MAQ was re-administered as a posttest. Standardized administration procedures were maintained across both groups to ensure consistency.

3.7 Data Analysis

Data were analysed using descriptive and inferential statistics. Mean and standard deviation were used to summarise students' attitude scores. Analysis of Covariance (ANCOVA) was employed. Prior to conducting ANCOVA, the assumption of homogeneity of variance was assessed using Levene's test. The result was not statistically significant, indicating that the error variances were homogeneous across the instructional groups. All statistical tests were conducted at the 0.05 level of significance.

4 Results

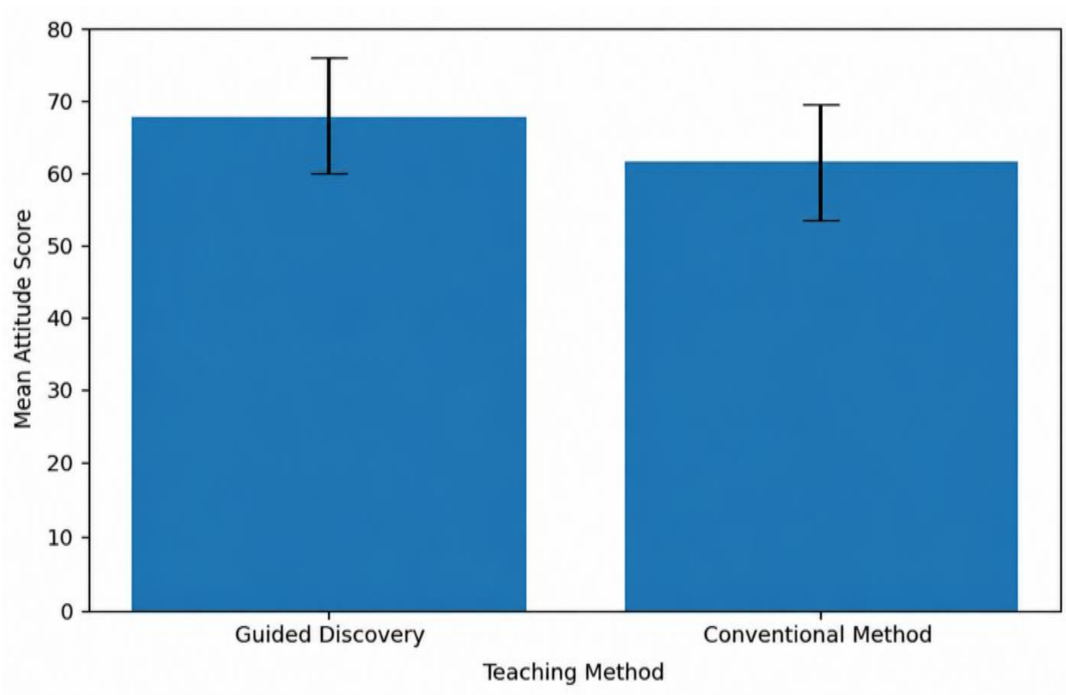
4.1 Research Question

What is the difference in the attitudes toward mathematics between students taught using Guided Discovery Strategy and those taught using conventional lecture method?

To address this research question, descriptive statistics (mean and standard deviation) of students' posttest scores on the Mathematics Attitude Questionnaire (MAQ) were computed and presented in Figure 1.

Figure **1**

Comparison of Mean attitude scores for teaching methods



The Figure 1 presents the mean attitude scores of students taught using Guided Discovery Strategy and Conventional Method. The Guided Discovery group recorded a mean score of 67.61, while the Conventional group recorded a mean score of 60.80. Error bars indicate variability within each group.

4.2 Null Hypothesis

There is no significant difference in the attitudes toward mathematics of students taught using Guided Discovery Strategy and those taught using conventional lecture method.

To test the null hypothesis, an Analysis of Covariance (ANCOVA) was conducted using students' pretest attitude scores as the covariate. Prior to conducting the analysis, the assumption of homogeneity of variance was assessed using Levene's test. The result was not statistically significant, $F(1, 140) = 0.071$, $p = .790$, indicating that the error variances were homogeneous across the Guided Discovery and conventional instruction groups. The ANCOVA results are presented in Table 2.

Table **2**

ANCOVA of Students' Attitude Scores by Instructional Method

Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F-vlaue**	**p-value**	**Partial Eta Squared**
Corrected Model	9647.271[a]	2	4823.635	1202.443	<.001	.945
Intercept	386.363	1	386.363	96.313	<.001	.409
Pretest	8000.708	1	8000.708	1994.428	<.001	.935
Group	15.296	1	15.296	3.813	.053	.027
Error	557.603	139	4.012			
Total	596454.000	142				
Corrected Total	10204.873	141				

a. R Squared = .945 (Adjusted R Squared = .945)

The ANCOVA results presented in Table 1 show that, after controlling for students' pretest attitude scores, the effect of instructional method on posttest attitude scores was not statistically significant, $F(1, 139) = 3.813$, $p = .053$, partial $\eta^2 = .027$. Therefore, the null hypothesis was not rejected. Although the descriptive results indicated that students taught using Guided Discovery Strategy obtained a higher mean attitude score ($M = 67.61$, $SD = 7.99$) than students taught using conventional instruction ($M = 60.80$, $SD = 7.64$), the difference was not statistically significant after controlling pretest attitude scores. The pretest attitude score was a statistically significant covariate, $F(1, 139) = 1994.428$, $p < .001$, partial $\eta^2 = .935$, indicating that students' pre-intervention attitude scores were strongly associated with their post-intervention attitude scores. The overall ANCOVA model was statistically significant, $F(2, 139) = 1202.443$, $p < .001$, with an R^2 of .945. This indicates that the overall model, comprising the pretest attitude score and instructional group, accounted for 94.5% of the variance in posttest attitude scores. However, this R^2 value should not be interpreted as indicating that the instructional method alone explained 94.5% of the variance. Rather, the very high proportion of explained variance was largely associated with the pretest covariate, as reflected in its very large partial eta squared (partial $\eta^2 = .935$), whereas the unique effect of instructional group was small (partial $\eta^2 = .027$) and not statistically significant.

4.3 Summary of the major findings

1. Students taught using Guided Discovery Strategy obtained a higher mean attitude score toward mathematics ($M = 67.61$, $SD = 7.99$) than students taught using conventional lecture method ($M = 60.80$, $SD = 7.64$).
2. After controlling for pretest attitude scores, the difference in posttest attitude scores between the Guided Discovery and conventional instruction groups was not statistically significant, $F(1, 139) = 3.813$, $p = .053$, partial $\eta^2 = .027$.
3. The null hypothesis was therefore not rejected, indicating that Guided Discovery Strategy did not produce a statistically significant effect on students' overall attitudes toward mathematics compared with conventional instruction.
4. Students' pretest attitude scores were strongly associated with their posttest attitude scores, $F(1, 139) = 1994.428$, $p < .001$, partial $\eta^2 = .935$, indicating that prior attitudes were a major predictor of post-intervention attitudes.

5 Discussion

The main purpose of this study was to examine whether the Guided Discovery Strategy (GDS) significantly influences students' attitudes toward mathematics compared to the conventional teaching method. The ANCOVA results indicated that although students taught using GDS recorded higher mean attitude scores than those taught using the conventional method, the difference was not statistically significant at the 0.05 level, $F(1, 139) = 3.813$, $p = .053$, partial $\eta^2 = .027$. This implies that the observed difference in attitudes between the two groups was small and not strong enough to be considered statistically meaningful after controlling for pretest scores.

The findings partially align with previous studies that report positive effects of guided and discovery-based instructional approaches on students' affective outcomes in mathematics. For instance, Ndaba (2021) and Sari et al. (2019) found that discovery-based learning enhances engagement and improves attitudes by making mathematics learning more interactive and meaningful. Similarly, Guntoro (2024) reported reductions in mathematics anxiety and improvements in students' confidence. In the present study, although the effect was not statistically significant, the descriptive results still indicated higher mean attitude scores for the Guided Discovery group. This pattern is consistent with earlier studies such as Asanre et al. (2022), Inyang et al. (2023) and Yusuf (2020), which reported positive directional effects, even when magnitude varied. However, the current finding contrasts with studies such as Post and Van Der Molen (2021), which reported statistically significant improvements, suggesting that the effectiveness of Guided Discovery may depend on contextual or implementation conditions.

The non-significant effect may be explained by several factors. One plausible explanation is the duration of the intervention. Attitudinal change is generally gradual and may require prolonged exposure to student-centred instructional strategies before significant shifts become observable. A six-week intervention may therefore be insufficient for substantial attitudinal transformation. Another explanation relates to variation in implementation fidelity across classrooms. Differences in teacher experience, instructional delivery and classroom management may have influenced how effectively the strategy was applied. In addition, the strong influence of pretest scores suggests that students' prior attitudes toward mathematics played a dominant role in shaping posttest outcomes, thereby limiting the observable effect of the instructional treatment.

The findings provide partial support for Social Constructivist Theory (Vygotsky, 1978), which emphasizes that learning occurs through active engagement and social interaction. The higher mean attitude score in the Guided Discovery group is consistent with this perspective, as students were actively involved in constructing mathematical knowledge. However, the absence of statistical significance suggests that active engagement alone may not be sufficient to produce strong attitudinal change. This is further supported by Expectancy-Value Theory, which posits that students' attitudes are shaped not only by instructional experiences but also by their expectations of success and perceived value of mathematics. Where such beliefs are already established, short-term instructional changes may have limited influence.

6 Implications of the Findings

The findings of this study have important implications for mathematics instruction. First, they indicate that while Guided Discovery Strategy may improve students' attitudes toward mathematics, the effect may be weak or not immediate when used in isolation. This suggests that instructional strategy alone is insufficient to produce substantial affective change. Second, the results highlight the critical role of students' prior attitudes in shaping learning outcomes. This implies that efforts to improve attitudes toward mathematics should begin early and be sustained over time rather than relying on short-term instructional interventions. Finally, the findings suggest that Guided Discovery Strategy may be more effective when combined with other pedagogical approaches that explicitly target motivation, confidence and emotional engagement in mathematics learning.

7 Limitations of the Study

This study is limited by its relatively short intervention period, which may not adequately capture long-term changes in students' attitudes. The use of intact classes, while appropriate for school-based research, limits full randomization and may introduce pre-existing group differences. In addition, the reliance on quantitative measures alone may not fully capture the complexity and depth of students' attitudes toward mathematics.

8 Recommendations for Future Research

Future studies should adopt longer intervention periods to allow sufficient time for attitudinal changes to develop and stabilize. Mixed-method designs are also recommended, as they can provide richer explanations of how and why students' attitudes change. Furthermore, future research should investigate the integration of Guided Discovery Strategy with motivational and affective support strategies to enhance its effectiveness in improving students' attitudes toward mathematics.

9 Conclusion

This study examined the effect of the Guided Discovery Strategy (GDS) on students' attitudes toward mathematics compared with the conventional teaching method. The findings indicated that although students taught using GDS demonstrated higher mean attitude scores than those taught using the conventional approach, the difference was not statistically significant after controlling for pretest scores. This suggests that the instructional method, in its current implementation, had a limited direct effect on students' attitudes toward mathematics. The study demonstrates that students' prior attitudes played a more influential role in determining post-intervention outcomes than the teaching strategy alone. The research objectives were therefore achieved by establishing the comparative effect of GDS and conventional lecture method on students' attitudes and determining the extent to which the observed differences were statistically meaningful.

In terms of contribution, the study adds to existing evidence on mathematics instruction by showing that Guided Discovery Strategy may produce positive but weak attitudinal effects within short intervention periods. It also reinforces theoretical perspectives that emphasise the combined influence of instructional practices and learners' pre-existing beliefs on attitude formation. The study underscores the practical need for sustained and multi-dimensional instructional interventions if meaningful improvements in students' attitudes toward mathematics are to be achieved. Future research should consider extended intervention durations and integrated pedagogical approaches to further explore how student attitudes can be more effectively improved.

10 Ethical Statements

This study was conducted in accordance with established institutional and administrative procedures for research involving human participants in school settings. Although formal ethical committee approval was not obtained from a registered ethics board, access to the study sites was granted through an official administrative approval process. An introductory letter from the Department of Science Education, Ahmadu Bello University, was used to obtain permission from the Kaduna State Ministry of Education, which subsequently authorized the study in selected secondary schools. Approval from the Ministry was used to secure consent from school principals. Participation of students was voluntary, with the purpose of the study explained prior to involvement and confidentiality of responses was ensured. No coercion was applied and respondents were assured that participation or non-participation would not affect their academic standing. Although written informed consent forms were not administered, verbal assent was obtained from participants with school authorities acting in loco parentis and data were used strictly for academic purposes.

11 Conflict of Interest

The authors declare no financial, commercial or other relationships that could be construed as a potential conflict of interest.

12 Author Contributions

IA: Conceptualization, Methodology, Investigation, Writing Original Draft. **DB**: Writing Original Draft, Writing Review & Editing, Validation. **KBD**: Data Curation, Formal Analysis, Visualization, Writing Review & Editing. All authors contributed to the study design, critically reviewed the manuscript, approved the final version for publication and agree to be accountable for all aspects of the work.

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15 Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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