Faculty of Natural and Applied Sciences Journal of Mathematics and Science Education
Print ISSN: 2814-0885 e-ISSN: 2814-0931
www.fnasjournals.com
Volume 6; Issue 3; May 2025; Page No. 47-58.

Effects of Inquiry and the Ashmore Problem-Solving Model on Performance and Attitudes in Trigonometry Among Senior Secondary School Students in Rivers East Senatorial District, Nigeria

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Abstract
The study investigated the effects of Inquiry-Based Learning (IBL) and the Ashmore Model on senior secondary school students' performance and attitude toward trigonometry in Rivers State, Nigeria. A quasi-experimental pretest-posttest control group design was employed. A multistage sampling technique was used to select 398 SS2 students from six intact classes across six public senior secondary schools. Two instruments, the Trigonometry Performance Test (TPT; reliability = 0.73) and the Students' Trigonometry Attitude Questionnaire (STAQ; $\alpha = 0.78$), were used for data collection. Data were analyzed using mean, standard deviation, ANCOVA, and Bonferroni Post Hoc Pairwise Comparison at a 0.05 significance level. Results showed that students taught using IBL and the Ashmore model performed significantly better than those taught with the lecture method ($F(2, 394) = 35.15$, $p < .001$, $\eta^2 = .151$), with mean gains of 10.47 (IBL), 9.26 (Ashmore), and 4.10 (Lecture). Attitude scores also favored IBL (mean gain = 11.59) over Ashmore (9.24) and Lecture (5.51) groups ($F(2, 394) = 41.89$, $p < .001$, $\eta^2 = .175$). Although males slightly outperformed females in the IBL group and females outperformed males in the Ashmore group, gender differences were not statistically significant ($F(1, 265) = 0.102$, $p = .750$). The study recommends the use of interactive and inquiry-driven strategies to enhance students' engagement, performance, and attitudes in trigonometry.

Keywords: Inquiry-Based, Ashmore Model, Performance, Attitude, Trigonometry

Introduction
Mathematics is essential for scientific and technological development, promoting logical reasoning, accuracy, and problem-solving skills (Anaduaka & Okafor, 2021). According to Asanre (2024), mathematical concepts form the foundation upon which nearly all scientific disciplines build and explain their theories, models, and frameworks. One of its crucial branches is trigonometry, which plays a significant role in engineering, physics, and astronomy (Bekene & Machaba, 2022). Trigonometry studies relationships between angles and lengths in triangles and strengthens students' cognitive abilities by enhancing reasoning and proof skills (Sulistyaningsih, 2021). Despite the importance of trigonometry, and its applications in everyday activities, many students find it challenging due to its abstract concepts and complex formulas (Abdullahi, 2022). The West African Examinations Council (WAEC, 2022) Chief Examiner's Reports indicate that students struggle with problems related to bearings, distances, and angles of elevation and depression, contributing to poor performance. Factors such as ineffective teaching methods and over-reliance on rote memorization have been linked to students' difficulties in understanding trigonometry (Tyata et al., 2021). Simons and Wibawa (2021) also noted that the fragmentation of concepts, extensive terminology, and abstract formulas make the subject even more significantly affect their success and that effective instructional strategies can enhance these attitude. To improve students' understanding, researchers suggest adopting constructivist teaching strategies, which focus on active learning and student engagement (Adolphus et al., 2022). Inquiry-Based Learning and problem-solving models have been identified as effective alternatives to conventional teaching methods (Ekon et al., 2017). Inquiry-Based Learning is a pedagogical approach that encourages students to ask questions, explore problems, and generate their own understanding; it has been shown to enhance conceptual learning in various disciplines, including mathematics (Grillo, 2024). According to Fadzil (2017), students engaged in the Inquiry-Based

Learning generate more meaningful knowledge than in passive learning modes. These approaches encourage students to explore concepts independently, fostering deeper understanding and critical thinking. Studies have shown that conventional methods fail to enhance students' problem-solving skills, leading to declining performance in mathematics (Onyeka & Charles-Ogan, 2021; Akpan et al., 2022). According to Aladejana (2022), teacher-centered teaching methods that do not allow student involvement have been identified as a major cause of student learning difficulties in mathematics.

VanGundy (2004) affirms that problems are new situations encountered by individuals that serve as obstacles between them and their desired goals. Such situations require inquiry and investigation to overcome. Similarly, problem solving is defined as the ability to address these challenges by collecting relevant facts and applying an understanding of mathematical concepts (Miftah et al., 2021). Importantly, problem-solving skills are recognized as a central goal in mathematics education, demanding that individuals think systematically, logically, and critically, and persist until a viable solution is found (Afriansyah et al., 2020). Within this process, reasoning plays a pivotal role. Students with strong reasoning skills are more capable of effectively resolving the problems they encounter (Agustin et al., 2024). Reasoning ability, therefore, is a vital aspect of mathematics that encompasses logical, analytical, and critical thinking patterns (Saputri & Herman, 2022). As highlighted in the curriculum, reasoning is a key component of higher-order mathematical thinking and is considered a foundational competency that all students must master (Kusumawardani et al., 2018). Imotor et al., (2024) noted that efforts to develop instructional strategies to enhance students' problem-solving abilities in science education have led to the creation of various problem-solving models. The Ashmore et al., (1979) problem-solving model are designed to help students to solve problems by proceeding in a logical sequence from a problem state to a solution state. The investigator is of the opinion that if these problem-solving models are used to teach trigonometry problems, the students are likely to be better improved in terms of conceptual thinking, intuitive knowledge and insightful learning. Such students are also likely to display an improved level of achievement.

The Ashmore Model provides a structured framework that guides students through a logical sequence from identifying a problem to evaluating its solution (Ashmore et al., 1979). The model comprises four distinct phases, which align with the instructional strategies adopted by teachers to enhance students' problem-solving skills. According to Ashmore and colleagues, effective problem solving requires the integration of four components: a solid understanding of the problem's background, access to relevant materials and tools, the ability to apply gathered information, and a process of evaluation. The first phase involves defining the problem, clearly identifying what needs to be solved. The second phase focuses on selecting the appropriate information that will assist in formulating a solution plan. In the third phase, the learner synthesizes the gathered information to develop and execute a solution strategy. The final phase is evaluation, where the implemented plan is assessed to determine whether it effectively resolved the original problem. The Ashmore Model is applicable to both numerical and non-numerical problems and is especially valued for its emphasis on reasoning. Its logical, step-by-step nature promotes critical thinking and analytical skills, making it a suitable instructional model for various contexts within science and mathematics education.

Gender roles and perceptions in science education remain complex. Ezeanyi and Okigbo (2021) affirmed that gender is a specially instructed phenomenon that is brought about as society ascribes different roles, duties, behaviours and mannerisms to the two sexes. Gimba (2017) agreed that bias is very prevalent in Africa and particularly Nigeria. He argued that in Nigeria, harder task are assign to males while females are given the relatively easy and less demanding tasks. Also Ebisine (2017) reported that gender has no effect on student achievement in science while Montague (2018) found that female subjects were significantly better than their male counterparts. The consensus among science educators is that some instructional strategies are gender bias while some are gender friendly. Given these concerns, this study seeks to examine the effect of Inquiry-Based Learning and the Ashmore Model in enhancing trigonometry learning outcome among secondary school students in Rivers East senatorial district.

This study is also motivated by the need to identify effective teaching methods that enhance concept understanding and student engagement. The Ashmore model has been noted for its effectiveness in promoting students' understanding in mathematics (Iberedem & Nsibiet, 2023). Additionally, previous studies have shown that problem-solving instructional strategies significantly improve students' academic achievement compared to traditional teaching approaches (Adeyanju, 2020; Folake & Ibidiran, 2021). However, research on the effectiveness of these methods in trigonometry instruction remains limited. Therefore, this study aims to bridge

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this gap by investigating how inquiry-based learning and the Ashmore model influence students' performance and attitude in trigonometry.

Statement of the Problem

There is a pressing need to critically examine the instructional approaches and techniques employed in teaching challenging topics such as trigonometry at the secondary school level. Despite its importance in science and technology, students continue to struggle with trigonometry due to ineffective teaching methods (Suleiman et al., 2021). While various strategies have been proposed for improving mathematics instruction, few specifically address the challenges of teaching trigonometry (Oni, 2021). Many students find it difficult to understand key concepts, leading to poor performance (Tyata et al., 2021).Results of studies conducted on mathematics performance and the deteriorating students' achievement in the subject clearly demonstrate the failure of these teaching methods of learning by rote memorization of formulas and facts (Onyeka & Charles- Ogan, 2021). The West African Examination council (WAEC, 2022) Chief Examiners' Reports confirm that students frequently make process errors when solving trigonometric problems, particularly in bearings, sine and cosine rules, and proving identities. This may be due to both ineffective teaching methods and students' negative attitudes toward the subject. Given these challenges, the study investigates impact of Inquiry-Based and Ashmore model in enhancing trigonometry learning outcome among secondary school students in Rivers state. The objective is to assess the extent to which these instructional approaches improve comprehension, participation, and academic outcomes in the subject.

Aim and Objectives of the Study

The aim of the study is to investigate the effect of Inquiry-Based Learning and Ashmore Model on performance and attitude in trigonometry among Senior Secondary Student in Rivers East Senatorial District. Specifically, the study seeks to:

1. Determine the effects of Inquiry-Based Learning and Ashmore Model on students' academic performance in trigonometry among senior secondary school
2. To examine the influence of Inquiry-Based Learning and the Ashmore model on the attitude of senior secondary school students toward trigonometry.
3. Examine the difference in the academic performance of male and female students taught trigonometry using Inquiry-Based Learning and Ashmore Model

Research Questions

The following research questions were raised to guide the study:

1. What is the difference in the mean performance scores of students exposed to trigonometry instruction using Inquiry-Based Learning, Ashmore Model and Lecture Methods?
2. What is the difference in the mean attitude score of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods?
3. What is the difference in the academic performance of male and female students taught trigonometry using Inquiry-Based Learning and Ashmore Model.

Hypotheses

The following hypotheses were formulated for the study and tested at 0.05 level of significance

1. There is no significant difference in the mean academic performance scores of students taught trigonometry using Inquiry-Based Learning, Ashmore model and lecture methods.
2. There is no significant difference in the mean score of the attitude ratings level of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods.
3. There is no significant difference in the academic performance of male and female students taught trigonometry using Inquiry-Based Learning and Ashmore Model

Material and Methods

The study adopted a quasi-experimental research design, specifically utilizing a pretest-posttest non-equivalent group format. The research was conducted in the Rivers East Senatorial District of Rivers State. The target population comprised all students enrolled in public senior secondary schools within the district. Rivers East Senatorial District consists of eight Local Government Areas and includes a total of 105 public senior secondary schools. Across these schools, there are approximately 83,261 students at the senior secondary level. Source:

(Planning, Research & Statistics Department, Rivers State Senior Secondary Schools Board, Port Harcourt). Multistage sampling procedure was used to engage more than two sampling methods for this study. At the first stage, the district was clustered into 4 area based on cultural similarity as shown, (Etche and Omuma), (Ikwerre and Emohua), (Obio/Akpor and Port Harcourt) and (Okrika and Ogu-Bolo). Then, a simple random technique using balloting was applied to choose three clusters out of four clusters based on cultural similarity. In the second stage, one Local Government Area (LGA) was randomly selected from each of the chosen clusters through a simple random sampling approach. Thus, a total of three local government areas were drawn for the sample for this study. Stage 3: Convenience sampling technique was used to pick two schools each from the three local government areas drawn for the study. That is a total number of six schools were sampled for the study. These schools were easily accessed by the researcher. Stage 4: Purposive sampling technique was used to engage only SS2 students in the school for the study. The reason was that trigonometry is a topic on SS2 scheme of work in mathematics curriculum. In addition SS2 students' was chosen because the students have already acquired substantial knowledge at SS1, and also they were not an examination class. Stage 5: Random sampling technique was used to draw out one intact class from each sample school for the study, intact classes were used due to the constraints of school organization and the ethical consideration of minimizing disruption to regular instructional activities, which gives a total of 6 intact classes that consist of 398 SS2 students (202 male and 196 female) which was used for the study. Four of the intact classes were assigned to the experimental groups, two to the Inquiry-Based Learning and two to the Ashmore Model while the remaining two served as the control group (Lecture method). The uneven distribution was necessary to ensure that each experimental model was implemented in more than one setting, thereby enhancing the external validity and reliability of the intervention outcomes.

Two research instruments were used for data collection in this study, namely: Trigonometry Performance Test (TPT) used to assess academic performance and Students' Trigonometry Attitude Questionnaire (STAQ) to measure student attitude. The Trigonometry Performance Test (TPT) was a multiple choice instrument designed and used to measure students' performance in trigonometric concepts; each item comprised four options (A–D), with only one correct answer. The content of the test was drawn directly from the SS2 curriculum and covered key trigonometry topics such as: Trigonometric ratios (sine, cosine, tangent), trigonometric identities and equations, angle of elevation and depression and sine and cosine rules. It was the same version of TPT that was used as pre-test and posttest to ascertain students' level of understanding trigonometric concept before and after the treatment. And the second instrument was the Students' Trigonometry Attitude Questionnaire (STAQ) instruments which comprised 20 items designed to assess students' attitudes toward learning trigonometry, adapted from existing attitude scales and aligned with the affective domain of Bloom's taxonomy. It measured four key domains: enjoyment of trigonometry, confidence in solving trigonometric problems, perceived usefulness of trigonometry and willingness to engage in future trigonometric tasks. The questionnaire was constructed based on four–points Likert- Scale of Strongly Agree (SA)=4, Agree (A)=3, Disagree (D)=2 and Strongly Disagree (SD)=1 respectively. The instruments were validated by three experts. Suggestions from them and that of researcher's supervisors were incorporated in the production of the final version of the instrument to ensure they are valid before administering to students. A table of specification showing an equal distribution of the test items over the concepts taught was handed over to the experts for their judgment. The reliability of the Students' Trigonometry Attitude Questionnaire (STAQ) and the Trigonometry Performance Test (TPT) was determined using appropriate methods for each instrument. The reliability of the Trigonometry Performance Test (TPT) was determined through the test-retest technique, in which the instrument was administered on two occasions separated by a two-week interval, following the recommendation of Sambo (2005). The resulting scores from both administrations were analyzed using the Pearson Product-Moment Correlation Coefficient (PPMCC) with the assistance of the Statistical Package for the Social Sciences (SPSS), yielding a reliability coefficient of 0.73. On the other hand, the reliability of the STAQ was determined using the internal consistency method. The Cronbach's alpha coefficient was computed and a reliability value of 0.78 was obtained. This approach provides a broader method for assessing internal consistency.

The instructional strategies applied in teaching trigonometry concepts to the participants include the Inquiry-Based Strategy, the Ashmore Model, and the traditional Lecture Method. Detailed lesson plans were developed to guide the teaching of selected trigonometric topics. The intervention period lasted six weeks and was implemented across two experimental groups and one control group. Prior to the commencement of the instructional phase, a letter of request for permission was taken to the Principals of the schools to be involved in the study. After obtaining the permission from the Principals, the researchers interacted with the mathematics teachers. The Trigonometry Performance Test (TPT) was administered as a pre-test to all groups by the researcher, assisted by trained teachers, to assess students' existing knowledge in trigonometry. Additionally, the Students' Trigonometry Attitude Questionnaire (STAQ) was given to all participants, and their responses and scores were recorded for analysis. To ensure confidentiality, no personal identifiers were used in the data collection instrument.

Data collected were analyzed using mean and standard deviation to answer the research questions while Analysis of Co-variance (ANCOVA) was used to test the null hypotheses at 0.05 level of significance. The ANCOVA was preferred because of its power to take care of the initial lack of equivalence (differences) in the experimental and control groups since intact classes were used for the study. The pretest served as covariate to the post test and this justifies more the use of ANCOVA for testing the null hypotheses.

Table 1
Sample of SS2 Students enrolled in public schools in the Rivers East region

Groups	**Nos of Schools in the selected LGA**	**Gender**		
		Male	**Female**	**Total**
Inquiry-Based	2	70	68	138
Ashmore model	2	67	63	130
Lecture Method	2	65	65	130
Total	6	202	196	398

Source: Field Survey, 2025

Results

Research Question 1: What is the difference in the mean performance scores of students exposed to trigonometry instruction using Inquiry-Based Learning, Ashmore Model and Lecture Methods?

Table 2: Summary of Mean and standard deviation of pre-test and post-test of Students Academic Performance across Inquiry-Based Learning, Ashmore Model and Lecture Methods

		Pre Test		**Post Test**		
Method	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Gain**
Inquiry	138	47.62	12.86	58.09	10.49	10.47
Ashmore model	130	45.25	13.80	54.51	9.88	9.26
Lecture method	130	47.92	8.62	52.02	6.46	4.1

Field Study, 2025

Result in Table 2 presents the mean and standard deviation of students' academic performance scores in trigonometry based on the instructional methods used: Inquiry-Based Learning, Ashmore Model, and Lecture Method. The results reveal that students in the inquiry group had a pre-test mean score of 47.62 (SD = 12.86) and a post-test mean of 58.09 (SD = 10.49), indicating a mean gain of 10.47. For the Ashmore Model group, the pre-test mean score was 45.25 (SD = 13.80), and the post-test mean was 54.51 (SD = 9.88), resulting in a mean gain of 9.26. In comparison, students in the Lecture Method group had a pre-test mean score of 47.92 (SD = 8.62) and a post-test mean of 52.02 (SD = 6.46), yielding a mean difference of 4.10. These findings suggest that while all three instructional methods led to improvements in students' performance, the Inquiry-Based Learning yielded the highest gain, followed closely by the Ashmore Model, with the Lecture Method resulting in the least improvement. This implies that the use of more interactive and student-centered instructional approaches, such as Inquiry-Based Learning and Ashmore models, may be more effective in enhancing students' academic performance in trigonometry than lecture-based teaching.

Research Question 2: What is the difference in the mean attitude score of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods?

Table 3: Summary of Mean and Standard deviation of pre-test and post-test attitude scores of Students in Inquiry-Based Learning, Ashmore Model and Lecture Methods

		Pre-Attitude		Post-Attitude		
Method	**N**	**Mean**	**SD**	**Mean**	**SD**	**Mean Difference**
Inquiry	138	91.90	5.82	103.49	5.08	11.59
Ashmore Model	130	92.51	5.67	101.75	5.26	9.24
Lecture Method	130	92.69	6.51	98.20	5.47	5.51

Table 3 presents the mean and standard deviation of students' attitude scores towards trigonometry before and after instruction using the Inquiry-Based Learning, Ashmore model, and Lecture Method. Students in the inquiry group recorded a pre-test mean score of 91.90 (SD = 5.82) and a post-test mean of 103.49 (SD = 5.08), resulting in a mean gain of 11.59. For the Ashmore Model group, the pre-test mean score was 92.51 (SD = 5.67), and the post-test mean was 101.75 (SD = 5.26), indicating a mean difference of 9.24. In the lecture method group, the mean score increased from 92.69 (SD = 6.51) in the pre-test to 98.20 (SD = 5.47) in the post-test, with a mean difference of 5.51. These findings suggest that all instructional methods led to improvements in students' attitudes toward trigonometry. However, the Inquiry-Based Learning group showed the greatest attitudinal gain, followed by the Ashmore Model, while the Lecture Method had the least impact. This implies that student-centered approaches such as Inquiry-Based and Ashmore Models may be more effective in promoting positive attitudinal change among students learning trigonometry.

Research Question 3: What is the difference in the academic performance of male and female students taught trigonometry using Inquiry-Based Learning and Ashmore Model?

Table 4: Means and Standard deviations of Male and Female students' performance in Inquiry-Based Learning and Ashmore Model.

Group	Gender	N	Mean	Std. Deviation	Mean Difference
Inquiry-Based Learning	Male	70	61.27	11.81	
	Female	68	54.82	7.73	6.45
Ashmore Model	Male	67	51. 81	9.86	
	Female	63	57.40	9.13	5.59

Table 4 presents the means and standard deviations of male and female students' academic performance in trigonometry when taught using Inquiry-Based Learning and Ashmore Model. The mean academic score of male students instructed through the Inquiry-Based Learning (M = 61.27, SD = 11.81) was higher than that of their female counterparts (M = 54.82, SD = 7.73), with a mean difference of 6.45 favoring the male students. This suggests that male students demonstrated superior performance under the Inquiry-Based Learning. In contrast, for students taught using the Ashmore Model, female students achieved a higher mean score (M = 57.40, SD = 9.13) compared to male students (M = 51.81, SD = 9.96), resulting in a mean difference of 5.59 in favor of the females. This indicates that female students performed better than their male peers when taught through the Ashmore Model.

Hypothesis 1: There is no significant difference in the mean academic performance scores of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods

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Table 5: ANCOVA Analysis on the Academic Performance of Students taught Trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	20546.487[a]	3	6848.829	179.823	.000	.578
Intercept	19571.617	1	19571.617	513.873	.000	.566
Pre_TPT	18038.148	1	18038.148	473.611	.000	.546
Method	2677.122	2	1338.561	35.145	.000	.151
Error	15006.066	394	38.086			
Total	1236864.000	398				
Corrected Total	35552.553	397				

a. R Squared = .578 (Adjusted R Squared = .575)

The results from Table 5 show that there was a statistically significant effect of the instructional method on students' post-test trigonometry performance scores, $F(2, 394) = 35.145$, $p < .001$, with a partial eta squared (η^2) of .151. This indicates that approximately 15.1% of the variance in post-test scores can be attributed to the instructional method used, after controlling for the influence of pre-test scores. Additionally, the covariate (Pre_TPT) also had a significant effect on post-test scores, $F(1, 394) = 473.611$, $p < .001$, $\eta^2 = .546$, suggesting that students' prior knowledge significantly influenced their post-instruction performance. The overall model was significant, $F(3, 394) = 179.823$, $p < .001$, with an R Squared value of .578 (Adjusted R Squared = .575), indicating that the model accounted for 57.8% of the variance in students' post-test performance. These findings suggest that the method of instruction plays a significant role in enhancing students' learning outcomes in trigonometry. Since it was established that there was a significant difference in the post-test scores of the groups, pairwise comparisons (post hoc tests) analysis was done to identify the direction of the difference among the treatment groups as shown in Table 5a

Table 5a: Summary of Bonferroni Post Hoc Pairwise Comparison Analysis of students' Academic performance scores among the group

(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Inquiry-Based	Ashmore Model	2.243*	.757	.010	.424	4.063
	Lecture Method	6.261*	.754	.000	4.447	8.074
Ashmore Model	Inquiry-Based	-2.243*	.757	.010	-4.063	-.424
	Lecture Method	4.017*	.769	.000	2.169	5.865
Lecture Method	Inquiry-Based	-6.261*	.754	.000	-8.074	-4.447
	Ashmore Model	-4.017*	.769	.000	-5.865	-2.169

Table 5a results indicated that all post hoc pairwise comparisons using Bonferroni adjustment showed that students taught using the **Inquiry-Based Learning** method scored significantly higher than those taught using the **Ashmore Model** (Mean Difference = 2.243, $p = .010$) and the **Lecture method** (Mean Difference = 6.261, $p < .001$). Similarly, students taught with the **Ashmore Model** outperformed those taught with the **Lecture Method** (Mean Difference = 4.017, $p < .001$). These findings suggest that the **Inquiry-Based Learning** approach was the most effective instructional strategy, followed by the **Ashmore Model,** with the **Lecture Method** being the least effective in enhancing students' performance in trigonometry. There was significant difference between the three groups, therefore, hypothesis one is rejected.

Hypothesis 2: There is no significant difference in the mean attitude scores of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and Lecture Methods.

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Table 6: ANCOVA Analysis on the Mean Attitude Ratings of Senior Secondary School Students in the Inquiry-Based Learning, Ashmore Model and Lecture Methods

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	3117.323[a]	3	1039.108	41.835	.000	.242
Intercept	9223.276	1	9223.276	371.338	.000	.485
Pre_STAQ	1187.729	1	1187.729	47.819	.000	.108
Method	2080.902	2	1040.451	41.890	.000	.175
Error	9786.165	394	24.838			
Total	4088268.000	398				
Corrected Total	12903.487	397				

a. R Squared = .242 (Adjusted R Squared = .236)

In Table 6, one-way **analysis of covariance (ANCOVA)** was conducted to examine whether students' attitudes toward trigonometry differed significantly among those taught using **Inquiry-Based Learning, Ashmore Model,** and the **Lecture Method,** after adjusting for their pre-attitude scores. The results showed a **statistically significant difference of instructional method** on students' post- attitude scores toward trigonometry, **$F(2, 394) = 41.890$, $p < .001$, partial $\eta^2 = .175$**. This indicates that approximately **17.5%** of the variance in students' post-attitude scores can be explained by the instructional method used, after controlling for pre-attitude scores. To identify where the significant differences occurred among the instructional methods, a Bonferroni-adjusted post hoc test was conducted. The pairwise comparisons revealed the following in table 6a.

Table 6a: Summary of Bonferroni Post Hoc Pairwise Comparison Analysis of students' Attitude scores among the groups

(I) method	(J) method	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b] Lower Bound	Upper Bound
Inquiry-Based	Ashmore Model	1.915*	.610	.005	.449	3.381
	Lecture Method	5.515*	.610	.000	4.048	6.981
Ashmore Model	Inquiry-Based	-1.915*	.610	.005	-3.381	-.449
	Lecture Method	3.599*	.618	.000	2.113	5.086
Lecture Method	Inquiry-Based	-5.515*	.610	.000	-6.981	-4.048
	Ashmore Model	-3.599*	.618	.000	-5.086	-2.113

Table 6a, showed the bonferroni post hoc pairwise comparison analysis of students' attitude scores among the groups. The results showed that students taught using the **Inquiry-Based Learning** reported significantly more positive attitudes toward trigonometry compared to those taught with the **Ashmore Model** (*Mean Difference* = 1.915, p = .005) and the **Lecture Method** (*Mean Difference* = 5.515, p < .001). Similarly, students exposed to the **Ashmore Model** demonstrated significantly more favorable attitudes than those in the **Lecture Method group** (*Mean Difference* = 3.599, p < .001). These results reject the null hypothesis, indicating that **instructional method significantly affects students' attitudes** toward trigonometry, with **Inquiry-Based Learning** producing the most positive attitudes, followed by the **Ashmore Model,** and lastly, the **Lecture Method**

Hypothesis 3: There is no significant difference in the academic performance of male and female students taught trigonometry using Inquiry-based learning and Ashmore model.

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Table 7: Summary of ANCOVA Result on Male and Female students' Performance scores.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	14932.980[a]	2	7466.490	145.587	.000
Intercept	18756.740	1	18756.740	365.733	.000
Pre_TPT	14910.354	1	14910.354	290.733	.000
Gender	5.230	1	5.230	.102	.750
Error	13590.632	265	51.285		
Total	879758.000	268			
Corrected Total	28523.612	267			

a. R Squared = .524 (Adjusted R Squared = .520)

Table 7 present the analysis of covariance (ANCOVA) on male and female students' performance scores when taught using Inquiry-Based Learning and Ashmore Model. The results revealed that there was no statistically significant difference in the post-test scores of male and female students after controlling for the pre-test scores, $F(1, 265) = 0.102$, $p = .750$, partial $\eta^2 = .000$. The covariate (Pre-TPT) was found to be statistically significant, $F(1, 265) = 290.733$, $p < .001$, indicating a strong relationship between pre-test and post-test performance. The overall model explained approximately 52.4% of the variance in students' post-test scores ($R^2 = .524$, Adjusted $R^2 = .520$). These findings suggest that gender did not have a significant effect on students' academic performance in trigonometry when taught using either Inquiry-Based Learning or the Ashmore Model, after accounting for prior achievement. Therefore, the null hypothesis is retained.

Discussion

The descriptive statistics in table 2 reveal the comparison of mean scores before and after the intervention showed that all groups improved in their performance, but with varying degrees. The Inquiry-Based Learning **group had the highest mean gain (10.47),** followed by the **Ashmore Model (9.26),** while the **Lecture Method group gained the least (4.10).** This implies that student-centered methods particularly Inquiry-Based Learning are more effective than the traditional lecture method in enhancing understanding of trigonometry. These findings align with previous studies (Grillo, 2023; Fadzil, 2017) that support active learning approaches in mathematics. This autonomy fosters deeper engagement, critical thinking, and understanding, particularly in abstract topics like trigonometry that require spatial reasoning and conceptual visualization (Sulistyaningsih, 2021).Constructivist theories also advocate for methods that allow students to build knowledge through inquiry and engagement (Adolphus et al., 2021). In contrast, the Ashmore Model though also structured and student-focused follows a more procedural approach to problem solving, guiding students through defined phases from problem identification to solution evaluation (Ashmore, Casey, & Frazer, 1979). While this method supports logical reasoning, it may limit the open-ended exploration that characterizes Inquiry-Based Learning. Students operating under Inquiry-Based Learning were likely better able to make meaningful connections between trigonometric principles and real-life contexts, enhancing both performance and interest (Grillo, 2023; Fadzil, 2017). The result (table 5) of the ANCOVA revealed a **statistically significant effect of instructional method on students' performance** ($F(2, 394) = 35.145$, $p < .001$), with Inquiry-Based Learning **and Ashmore Model outperforming the Lecture Method.** Post hoc analysis (Table 5a) showed that: Inquiry-Based Learning significantly outperformed Ashmore Model ($p = .010$) and lecture ($p < .001$) and Ashmore Model significantly outperformed Lecture Method ($p < .001$). These findings further confirm the **superiority of student-centered strategies,** particularly Inquiry-Based Learning, in promoting conceptual learning in trigonometry (Onyeka & Charles-Ogan, 2021; Saputri & Herman, 2022).

Similarly, table 3 presents descriptive statistic for **students' attitude toward trigonometry.** Students exposed to Inquiry-Based Learning recorded the greatest improvement in attitude scores (mean gain = 11.59), followed by the Ashmore Model (9.24), and the Lecture Method (5.51). This progression suggests that students respond more positively when instructional methods promote participation, independence, and relevance to real-world contexts. As supported by Akinoso (2016) and Bekene & Machaba (2022), teaching strategies that involve students actively in the learning process tend to improve not only performance but also motivation, confidence, and willingness to engage with mathematical tasks. Similar to performance, ANCOVA for attitude (Table 6)

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showed significant differences across groups ($F(2, 394) = 41.890$, $p < .001$). Post hoc tests (Table 6a) confirmed that: students in the Inquiry-Based Learning group developed significantly more positive attitudes than those in the Ashmore Model and Lecture Metthod groups and Ashmore Model also yielded more favorable attitudes than the Lecture Method. This confirms that methods fostering active participation and independence, as emphasized in the affective domain of Bloom's taxonomy, result in more engaged and motivated learners (Sulistyaningsih, 2021; Akinoso, 2016).

In terms of gender differences, the study found no statistically significant effect, which supports Ebisine's (2017) report that gender has no impact on achievement in science. This neutral outcome is also consistent with the findings of Iberedem and Nsibiet (2023), which showed that the effectiveness of Ashmore Models in mathematics transcends gender when properly implemented. While descriptive trend may reflect differences in learning preferences, where males may be more inclined toward open-ended inquiry, and females may thrive better in structured problem-solving formats. However, the overall implication is that both instructional models are **gender-responsive**, providing equitable benefits across male and female learners (Ebisine, 2017; Iberedem & Nsibiet, 2023). The study strengthens the importance of replacing lecture-based instruction with more engaging and participatory teaching approaches such as Inquiry-Based Learning and Ashmore models, particularly in complex subjects like trigonometry. These strategies are not only effective in improving students' cognitive outcomes but also in fostering positive attitudes and equitable participation across genders.

Conclusion

Based on the results of the study, it can be concluded that there was statistical significant difference in the mean attitude rates of students taught trigonometry using Inquiry-Based Learning, Ashmore Model and those taught using Lecture Method. The result also indicated that large effect of Inquiry-Based Learning and Ashmore models on students' performance was recorded in the trigonometry instructional delivery. The findings revealed that students taught using inquiry-based and Ashmore problem-solving model achieved higher academic performance and developed a more positive attitude toward trigonometry than those taught using the Lecture method. Furthermore, the study found that both male and female students benefitted equally from the innovative instructional approaches, with no statistically significant gender differences in performance. These results emphasize the importance of learner-centered instructional strategies in improving cognitive and affective outcomes in mathematics education. The study concludes that replacing traditional Lecture Methods with Inquiry-Based Learning and structured Ashmore Model can significantly enhance students' engagement, achievement, and disposition toward trigonometry.

Recommendations

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

1. Curriculum designer should incorporate Inquiry-Based Learning and Ashmore model strategies into the trigonometry curriculum to enhance student conceptual understanding and engagement.
2. The government, school administrators, and educational policymakers should organize regular professional development workshops to train mathematics teachers on the effective use of Inquiry-Based Learning and Ashmore Model techniques in the classroom.
3. At the policy level, teacher education institutions should revise their pre-services mathematics curricula to reflect current pedagogical advancements in Inquiry-based Learning and Ashmore Model that prepare future teaches for constructivist teaching in mathematics
4. Teachers should incorporate inquiry-based learning and the Ashmore problem-solving model into their teaching strategies to enhance students' engagement, conceptual understanding, and academic performance in trigonometry. This approach will help students develop critical thinking skills and a deeper understanding of mathematical concepts.

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