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Effects of Think Pair Share Strategy on the Academic Achievement in Trigonometry among Senior Secondary Schools Students in Bauchi Education Zone, Nigeria

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ABSTRACT
The study investigated the effects of Think-Pair-Share (TPS) strategy on academic achievement in Trigonometry among senior secondary school students in Bauchi Education Zone, Nigeria. Two (2) research objectives, Two (2) research questions and One corresponding null hypothesis were raised to guide the study. The study employed Sequential explanatory mixed method research design. The population of the study comprised Twenty-Six Thousand Seven Hundred and Forty-One (26,741) SS2 students in public secondary schools within Bauchi Education zone. One Hundred and Twenty-One (121) students were used as sample for the quantitative phase selected using simple random sampling technique from two schools. In addition, interviews were conducted to selected Nine (9) students to complement the quantitative data and provide deeper insights into students' experiences with TPS. Two instruments were developed and validated for the study: Trigonometry Achievement Test (TAT), and Interview Protocol. Content Validity Indices (CVI) revealed 0.89. The difficulty and discrimination indices for the TAT revealed a mean score of 0.46 and 0.40 respectively. The face validity analysis revealed an overall percentage agreement of 85%, corresponding to a Kappa value of 0.855. Indicates the items were appropriate, clear, and relevant for determining students' academic achievement in trigonometry. Reliability was determined using split half method yielding coefficients of 0.75, indicating high consistency and dependability. The reliability of the interview protocol was found to be 0.76 determined using inter- rater reliability method. Data were analysed using mean, standard deviation, ANCOVA, and qualitative thematic analysis. The findings revealed that students taught using TPS recorded significant difference in the mean academic achievement scores than those taught with the conventional lecture method. The qualitative findings from the students' responses with use of TPS revealed a remarkable 25% improvement in their confidence, followed by 21.4% in both performance and retention each while understanding stood at 17.9% and reasoning at 14.3%. It was concluded that TPS is an effective strategy capable of improving academic achievement, in trigonometry in Bauchi Education Zone secondary schools. It is recommended that mathematics teachers should adopt TPS in teaching challenging topics such as

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Trigonometry, and that curriculum planners, school administrators, and teacher-training institutions should integrate TPS principles into instructional guidelines and professional development programs to enhance students' learning outcomes.

INTRODUCTION

Education is universally recognized as a deliberate, organized, and continuous process through which societies transmit knowledge, skills, values, and cultural norms across generations (Eyong, 2019). It offers individuals the intellectual tools and moral foundations needed for personal development, social cohesion, and national progress (Mohammed & Charles, 2017). Among school subjects, mathematics holds a particularly strategic position due to its role in promoting logical reasoning, quantitative literacy, abstraction, and problem-solving competence (Boaler, 2016). Its value transcends disciplinary boundaries, contributing significantly to science, engineering, commerce, technological innovation, and informed citizenship (Badru, 2025). In Nigeria, mathematics remains a compulsory subject for all basic and secondary school students due to its importance for tertiary admission and national manpower development (Olofinlae, 2023). However, despite this emphasis, persistent challenges continue to undermine students' performance and attitudes toward mathematics at different educational levels.

Within the broad mathematics curriculum, trigonometry constitutes a crucial but challenging area for many secondary school learners. Trigonometry introduces students to the study of angles, triangles, and periodic functions, encompassing key concepts such as sine, cosine, tangent, angle of elevation and depression, bearings, and trigonometric identities (McKeague, 2017; Lial et al., 2019). These concepts form the foundational knowledge necessary for advanced studies in physics, engineering, architecture, aviation, computer graphics, and navigation. Yet, numerous studies reveal that trigonometry is among the least understood aspects of the secondary school mathematics curriculum (Orhun, 2015; Muawiya & Mukhtari, 2017; Thomas, 2022). Many learners struggle with visualizing geometric relationships, translating verbal descriptions into diagrams, and applying trigonometric ratios accurately.

Evidence from West African Examinations Council (WAEC) repeatedly highlights widespread misconceptions and difficulty among candidates. WAEC Chief Examiner's Reports (2018, 2020, 2022 and 2024) consistently show that questions involving bearings, angles of elevation and depression, and diagrammatic representation are poorly answered. For instance, the 2020 report noted that many candidates misinterpreted a problem involving points X, Y, and P, failing to represent angles of elevation correctly and consequently missing the solution. These recurring issues indicate that many students lack conceptual understanding of trigonometric principles, which manifests in low achievement and poor performance in national examinations.

Scholars argue that these persistent difficulties stem from several factors, including the abstract nature of trigonometric concepts, poor instructional methods, limited use of visualization tools, and students' anxiety or negative dispositions toward mathematics (Hartnett & Gelman, 2019; Reta & Debre, 2019). In many Nigerian classrooms, instruction remains teacher-centered, emphasising rote learning, procedural memorisation, and repetitive exercises rather than conceptual reasoning and collaborative problem-solving (Akanmu, 2019; Alabi & Rasheed, 2019). These approaches often fail to stimulate students' interest or promote meaningful understanding, particularly when dealing with complex topics such as trigonometry.

To address these challenges, educational researchers have advocated for teaching methods that enhance understanding, stimulate curiosity, and promote active engagement. Approaches such as formative assessment, cooperative learning, peer instruction, problem-based learning, and reflective teaching have been shown to significantly improve students' outcomes in mathematics (Reta & Debre, 2019; Assuah et al.,

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2022). Among these, cooperative learning strategies have received substantial scholarly attention for their effectiveness in strengthening communication skills, building confidence, and improving conceptual understanding.

Think-Pair-Share (TPS), developed by Frank Lyman (1981), is a structured cooperative learning technique that consists of three phases: Think: Students reflect individually on a question or task. Pair: They discuss their ideas with a partner. Share: The pair shares their joint reasoning with the class. Recent studies demonstrate that TPS promotes higher-order thinking, encourages equal participation, and creates a supportive environment where students learn from each other's explanations (Olayiwola, 2025).

Research has shown that TPS enhances students' achievement, making it highly suitable for topics requiring conceptual clarity and multiple representations (Sunandar, 2023; Khaq & Febriana, 2022; Abiodun et al., 2023; Aneshie-Otakpa et al., 2023; Ibe, Ezeliora & Okafor, 2024). In trigonometry, where visualization and conceptual reasoning are vital, TPS can help students organize information, discuss representations, and build confidence in problem-solving. While TPS has been widely studied in relation to algebra, geometry, basic mathematics, and general classroom interaction (Akanmu, 2019; Alabi et al., 2025; Popoola & Olofinlae, 2023), there is limited research focusing specifically on the effects of TPS on students' achievement, in trigonometry in Nigeria. This study investigated the effect of Think Pair Share Strategy on the academic Achievement, in Trigonometry among Senior Secondary School Students in Bauchi Education zone.

Statement of the Problem

Trigonometry plays an important role in developing students' conceptual understanding of algebraic, geometric, and graphical reasoning (McKeague, 2017). Knowledge of trigonometry enables learners to link real-life situations with classroom activities and strengthens their thinking and problem-solving skills (Muawiya and Mukhtari 2017). Despite the significant contribution of trigonometry to mathematics at the secondary school level, students' achievement in the topic has remained persistently low. Evidence from the West African Examinations Council (WAEC) Chief Examiners' Reports shows that students' overall performance in mathematics between, 2020 to 2024 fluctuated considerably, as presented in Table 1. Although the reports indicate gradual improvement in mathematics results over the years. The Chief Examiners further observed that one of the persistent causes of students' poor performance in mathematics is their weak understanding of trigonometry. Many students struggle to interpret and represent trigonometric information in diagrams, avoid applying relevant formulae during problem solving, and become more confused when numerical operations are involved. These difficulties suggest that students lack adequate support in constructing meaning from trigonometric concepts.

Table 1: Distribution of the number of students that sat for Mathematics Examination Between 2020 – 2024

Year	**Total number of students that sat for mathematics Examination**			**Number of students that got credit in Mathematics Examination**			**Percentage**
	Male	**Female**	**Total**	**Male**	**Female**	**Total**	
2020	9356	8667	18023	5414	3268	8682	48.17
2021	11517	10940	22457	4780	4555	9335	41.57
2022	12710	9424	22134	9404	5591	14995	67.75
2023	8276	7561	15837	5691	3589	9280	58.60
2024	14833	11908	26741	6914	5946	12860	48.09

Bauchi State Ministry of Education, 2024

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To address this challenge, educators and researchers have been exploring innovative instructional approaches to enrich students' learning experiences and academic accomplishments in trigonometry (Lial et al, 2020). Among these strategies are the Think Pair Share (TPS) technique. TPS fosters collaborative learning by encouraging students to work in pairs, discuss ideas, and share insights before presenting them to the entire class, promoting active engagement, peer interaction, and deeper comprehension of mathematical concepts (Kagan, 1994). While various studies have explored the efficacy of TPS (Abiodun, et al, 2022; Adedeji 2021) in enhancing students' learning outcomes and engagement in mathematics (Pradana et al., 2017), limited research has investigated the impact of these strategy, particularly in the context of trigonometry at the senior secondary school level (Smith et al., 2017). Hence, this study aims to bridge this gap by examining the effectiveness of TPS in augmenting academic achievement, in trigonometry among senior secondary school students in Bauchi Education Zone.

Objectives of the Study

The main objective of this study is to investigate the effect of Think Pair Share strategy on Students' Academic Achievement, among Senior Secondary School in Bauchi Education Zone. Specifically, the study seeks to:

1. Determine the effect of Think Pair Share strategy on the academic achievement of Senior Secondary School Students in Trigonometry
2. Explore the views of students on the effect of Think Pair Share strategy on their academic achievement in Trigonometry.

Research Questions

1. What is the difference between the mean academic achievement of students taught Trigonometry using Think Pair Share strategy and those taught using conventional method?
2. What are the views of students on the effect of Think Pair Share strategy on their academic achievement in Trigonometry?

Research Hypothesis

The following null hypotheses were tested at 0.05 level of significance.

H_{01}: There is no significant difference between the mean academic achievement scores of students taught Trigonometry using Think Pair Share strategy and those taught using conventional methods

LITERATURE REVIEW

The Think-Pair-Share (TPS) strategy is one of the most widely used cooperative learning techniques for promoting active participation, collaborative reasoning, and student engagement in classroom environments. Developed by Frank Lyman in 1981, TPS was originally designed to shift the classroom from teacher-dominated discourse to more inclusive student interaction. The strategy involves three sequential stages: Think, where students independently reflect on a question or problem; Pair, where they discuss their ideas with a partner; and Share, where they present their conclusions to the larger group or class. This structured approach supports learners in organising their thoughts, refining their understanding, and articulating mathematical reasoning clearly (Lyman, 1981).

The suitability of TPS for teaching trigonometry stems from the nature of the subject itself. Trigonometry requires students to visualize and reason about relationships between angles, distances, heights, and directions. The abstract nature of trigonometric concepts often leads to misconceptions and cognitive overload when instruction is unidirectional. Through the Think stage, students internalize questions related to trigonometric ratios, bearings, or angles of elevation. During the Pair stage, students verbalize their reasoning, identify common misunderstandings, and compare solution strategies. The Share stage further consolidates these ideas by exposing students to diverse reasoning paths from their peers. This process

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supports the development of mathematical reasoning, improves students' communication skills, and builds a positive learning environment where learners are comfortable expressing their thoughts.

Contemporary studies across Africa, Asia, and Europe highlight the impact of TPS on mathematics achievement, engagement, and interest. Haakachima and Lunjebe (2019), in a Zambian study involving Grade 10 mathematics students, found that TPS significantly improved learners' problem-solving performance compared to traditional instruction. Their findings revealed that students in the TPS group demonstrated higher conceptual understanding and greater willingness to participate in class discussions. In Ghana, Aneshie-Otakpa et al. (2023) observed that TPS enhanced students' self-confidence and communication skills, enabling them to tackle challenging algebraic and geometric tasks with increased enthusiasm. The researchers reported that the collaborative nature of TPS contributed to reduced mathematics anxiety, one of the major barriers to performance in West African secondary schools.

In the Nigerian context, Ibe, Ezeliora, and Okafor (2024) conducted a quasi-experimental study on senior secondary school mathematics students and found a significant positive effect of TPS on learner engagement, interest, and achievement. Their research demonstrated that students taught with TPS were not only more active during lessons but also exhibited improved test scores and higher motivation to learn mathematics. The authors attributed this improvement to the strategy's ability to create a low-pressure environment where students felt supported by their peers. Similar studies in Bauchi, Lagos, and Anambra State reinforce that TPS promotes participatory learning, discussion-based reasoning, and increased conceptual clarity, particularly in topics perceived as difficult, such as geometry and trigonometry.

International literature also situates TPS within a larger framework of effective discourse strategies that promote high-level reasoning in mathematics classrooms. Lyman, McTighe, and Wiliam (2023) note that TPS enhances students' metacognitive abilities, allowing them to self-monitor and adjust their thinking processes. By encouraging learners to articulate their explanations and justify their solutions, TPS fosters the development of mathematical communication skills essential for deeper understanding. Furthermore, TPS is flexible and can be adapted to assessments, problem-solving tasks, project-based learning, and real-life mathematics applications.

The cognitive benefits of TPS are complemented by its socio-emotional impact. Communication with peers helps reduce mathematics anxiety, increase self-efficacy, and promote a sense of belonging. When students experience success through peer interaction, their confidence grows, which in turn improves their willingness to attempt challenging problems. This contributes to long-term improvements in achievement, variable central to the present study on trigonometry learning in Nigeria.

Empirical studies provide robust evidence of the positive effect of TPS on mathematics achievement. Zaki et al. (2024) conducted an experimental study involving secondary school students and found that those taught using TPS with higher-order thinking questions achieved significantly higher mathematics scores compared with those exposed to traditional instruction. The researchers attributed the gains to increased student discourse, enhanced peer scaffolding, and opportunities for immediate feedback during pair discussions (Zaki et al., 2024). Similarly, Suhari Ningsih, Pasaribu, and Harahap (2024) reported that TPS combined with Group Advisor Strategy significantly improved achievement in mathematics, suggesting that structured cooperative approaches enhance conceptual understanding and application of mathematical procedures.

Although fewer studies have focused solely on trigonometry, the evidence from related mathematics topics underscores the potential impact of TPS on trigonometric achievement. Mathematics researchers have shown that cooperative learning improves problem-solving skills, conceptual understanding, and retention, all of which contribute to improved performance in abstract topics like trigonometry (Prince, 2004;

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Freeman et al., 2014). When students engage in pair discussions, they articulate reasoning strategies, correct misconceptions, and formulate solutions collaboratively processes that strengthen neural connections and promote deeper learning.

In the Nigerian context, where teacher-centred methods remain prevalent, introducing TPS has been associated with improved achievement outcomes. Abiodun et al. (2022) found that senior secondary school students exposed to TPS scored higher in mathematics achievement tests than peers taught via lecture. Moreover, meta-analytic research has established that active learning strategies, including cooperative learning, yield consistent positive effects on student achievement across STEM fields (Freeman et al., 2014). By creating opportunities for peer interaction and shared sense-making, TPS addresses key barriers to achievement, such as student passivity, limited reasoning practice, and lack of immediate feedback that often characterize conventional instruction.

Theoretical Framework

The theoretical foundations of this study rests on Vygotsky's (1978) social constructivism. Vygotsky's (1978) social constructivism which posits that learning occurs through social interaction and shared meaning-making. A central element of Vygotsky's theory is the Zone of Proximal Development (ZPD) the gap between what a learner can accomplish independently and what they can achieve with guidance from a more knowledgeable peer or adult. The ZPD highlights the importance of instructional scaffolding, where teachers or peers provide temporary support that enables learners to engage in more complex cognitive tasks than they would manage alone (Chaiklin, 2003). In mathematics education, and particularly in trigonometry, learners often encounter abstract concepts that require support in visualising, interpreting, and applying relationships among angles, distances, and ratios. The ZPD therefore becomes a crucial framework for designing instruction that bridges students' current abilities and intended learning goals.

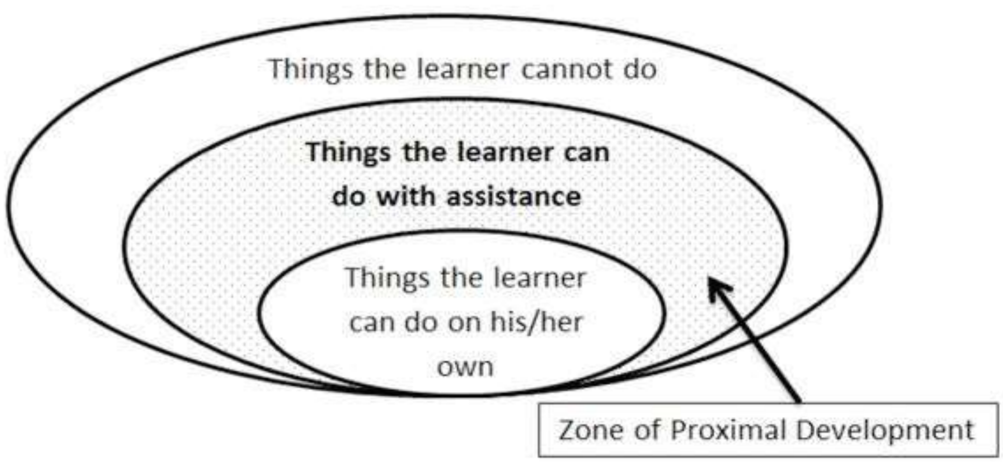

Fig. 1. Vygotsky's Zone of Proximal Development (Chaiklin, 2003)

The Think-Pair-Share (TPS) strategy is strongly anchored in social constructivist principles. The "Think" stage encourages students to activate prior knowledge and generate ideas individually, preparing them for deeper engagement. The "Pair" stage embodies the essence of the ZPD by enabling students to collaborate, question each other, clarify misunderstandings, and refine their thinking through peer interaction. During the "Share" stage, learners articulate their reasoning to the whole class, further constructing knowledge through dialogue, teacher facilitation, and

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exposure to diverse approaches. This sequence reflects Vygotsky's view that learning progresses from social interaction toward internalised understanding (Lyman et al., 2023).

In the context of trigonometry learning in Nigerian secondary schools, students frequently face difficulties with visualising and interpreting diagrams, solving contextual angle problems, and connecting trigonometric ratios to real-life applications. Social constructivism provides a mechanism for overcoming these challenges by ensuring that students are not left to grapple with concepts in isolation. When learners discuss their ideas with peers, misconceptions become visible, and correct reasoning is reinforced through explanation, negotiation, and collaborative sense-making (Tahir, Basri & Firdaus, 2020). Such interactions are especially powerful in topics like angles of elevation and depression, sine and cosine rules, and bearings, where students benefit from multiple representations and peer-supported reasoning.

Furthermore, social constructivism aligns closely with Nigeria's current emphasis on learner-centred education as articulated in the National Policy on Education (Federal Republic of Nigeria, 2023). The policy underscores the need for pedagogies that encourage active participation, critical thinking, and problem-solving core features of a constructivist classroom. Think-Pair-Share naturally operationalises these expectations by shifting the learning process from teacher-led demonstrations to student-led exploration and dialogue. Research evidence also reinforces this alignment: several studies show that cooperative learning environments rooted in constructivist principles lead to improved achievement, stronger engagement, and heightened interest in mathematics (Haakachima & Lunjebe, 2019; Aneshie-Otakpa et al., 2023; Ibe, Ezeliora & Okafor, 2024).

Additionally, social interaction plays a crucial motivational role. When students discuss problems in pairs or small groups, anxiety decreases, confidence increases, and learners develop a sense of belonging that supports persistence in challenging tasks. These affective benefits are consistent with Vygotsky's assertion that social context shapes cognitive growth, emotional development, and willingness to engage in learning. This becomes particularly important in trigonometry, a topic that many Nigerian students perceive as abstract or difficult. Through TPS, learners encounter a supportive environment where they can test ideas without fear of failure, learn from peers, and experience increased autonomy and competency.

METHODOLOGY

This study employed sequential explanatory mixed-method design. The Population comprised of all twenty-six thousand seven hundred and forty-one (26,741) SS2 students in the 117 public senior secondary schools in Bauchi educational zone in Bauchi State. A sample size of the study comprised of 121 SS2 students from two intact classes of the two selected Senior Secondary Schools in Bauchi Education zone. Purposive sampling technique was used to select Nine (9) students for the interview. Two instruments were used for data collection in the study were: Trigonometry Achievement Test (TAT), and Trigonometry Interview Protocol.

The Trigonometry Achievement Test (TAT), underwent both face and content validation The result of the face validity analysis for the TAT revealed an overall percentage agreement of 85.5%, corresponding to a Kappa value of 0.855. This value indicates a high level of agreement among the validators and suggests that the instrument possesses adequate face validity for use in the present study. The content validity index average S-CVI/Ave for TAT was 0.89, indicating a high level of content validity. Split-half reliability was determined to be 0.75, indicating a substantial level of internal consistency and reliability in the test scores. The Interview Protocol were given to one Professor and two Senior Lecturers for validation Their corrections were considered in the construction of the final instruments.

The reliability of the interview protocol was determined using inter- rater reliability method. The result of the reliability were found to be 0.76 which shows that the instrument is reliable and can be used in this research. TAT underwent item

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analysis to improve the quality of all items and the overall instrument by assessing their difficulty index and discrimination index. The results of the difficulty index and discriminating index of items in the Trigonometry Achievement Test (TAT) shows that all the multiple choice questions (items) in TAT fell in the difficulty index range between 0.08 - 0.49 The mean score of the difficulty indices of the test items was 0.46. It indicates that the questions were moderately difficult in all. The mean score of the discrimination indices of the items was 0.40 and shows that items were very discriminating.

Mean and Standard Deviation were used to answer the research questions one and two while one-way analysis of Co-Variance (ANCOVA), were used to test all the hypotheses at 0.05 level of Significance. The research question three was answered using qualitative thematic analysis.

RESULTS

Research Question One

What is the effect of Think Pair Share strategy on the academic achievement of Senior Secondary School Students in Trigonometry?

Table 2: Mean, SD and Mean Gain Difference of Pretest and Posttest Academic Achievement Scores of Experimental and Control Groups

Pretest				**Posttest**			
Group	**N**	**Mean**	**SD**	**Mean**	**SD**	**MG**	**MGD**
Experimental	59	32.54	6.40	48.68	6.22	16.14	13.51
Control	62	32.27	8.03	34.90	7.76	2.63	
Total	121						

Table 2 presents the Mean, Standard Deviation and Mean Gain Difference of Pretest and Posttest of Academic Achievement Scores of the Experimental and Control Groups. The result shows that the pre-test mean score of students in the experimental group that were taught using think pair share strategy prior to instruction was 32.54 while that of Control Group that were taught using lecture method is 32.27 with standard deviations of 6.40 and 8.03 respectively. The standard deviation obtained indicates that some students in the groups might have obtained higher or lower scores than the obtained mean.

The post-test mean score of students taught Trigonometry using Think Pair Share Strategy was 48.68 While those taught using lecture method is 34.90 with standard deviations of 6.22 and 7.76 respectively. The standard deviation obtained is an indication that there was less variability in the scores of students across the groups. The mean gain obtained after the intervention for Think Pair Share Strategy (Mean Gain = 16.14) and lecture method (Mean gain = 2.63) is an indication that the interventions had positive impact on the students' academic achievement due to improvements in their score in Trigonometry achievement test. The mean gain difference of 13.51 was established between students taught trigonometry using think pair share and those taught using lecture methods further confirms the superiority of the TPS over lecture method. To know whether the mean gain difference is significance or not, ANCOVA was used and the result is presented in table 3

Hypothesis One

H_{O1}: There is no significant difference between the mean Academic Achievement of students taught Trigonometry using Think Pair Share strategy and those taught using Lecture methods.

Table 3: ANCOVA Results of Academic Achievement Scores of the Experimental and Control Groups after the Treatment

Source	**Type III Sum of Squares**	**Df**	**Mean Squares**	**F**	**Sig**	**Partial Eta Squared**

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Corrected Model	260848.812[b]	2	130424.406	190.689	.000	.764
Intercept	53093.524	1	53093.524	77.626	.000	.397
Pretest	230662.037	1	230662.037	337.243	.120	.741
Group	27964.760	1	27964.760	40.886	.000	.257
Error	80707.682	118	683.963			
Total	9498305.000	121				
Corrected Total	341556.493	120				

Table 3 shows ANCOVA results of Academic Achievement scores of the Experimental and Control Groups after Treatment. The results shows that F (1, 118) = 40.886, p = .000, partial eta squared = .257 indicating a large effect size. Since the P value of 0.000 is less than P ≤ 0.05 level of significance, the null hypothesis which stated that there is no significant difference in the academic achievement of senior secondary school students taught trigonometry using Think pair share strategy and those taught using lecture method was therefore rejected in favour of students in the Think pair share strategy group. This implies that there was a significant difference in the mean academic achievement scores of students taught trigonometry using Think pair share strategy and those taught using Lecture methods after administration of the posttest while controlling scores in the pretest.

RESULTS OF QUALITATIVE ANALYSIS

Theme One: Impact of the Think-Pair-Share (TPS) Strategy on Students' Academic Achievement in Trigonometry

To address the theme one, the students' views were asked on the effect of the Think-Pair-Share (TPS) strategy on their academic achievement in trigonometry in Bauchi Education zone using the following questions.

Q1) How has think - Pair - Share helped you solve trigonometry problems better in class?
Q2) Can you describe any changes you noticed in your performance since you started learning through Think - Pair - Share?
Q3) What do you think about your understanding of trigonometry topics now compared to before?
Q4) Did discussing with your partner help you explain or reason through your answers more clearly?
Q5) Did you feel your ability to solve problems has improved since you started using this method? Why?
Q6) How confident do you feel when solving trigonometry questions after working with a pertner?
Q7) How has Think - Pair - Share changed the way you think about trigonometry problems?

The views of participants based on the questions above led to the development of five sub themes; Confidence, Performance, Reasoning, Retention and Understanding. Table 15 and figure 1 shows the link between main theme and sub - themes

Confidence

The first sub-theme that emerged from the analysis was **students' confidence for learning.** Confidence in this context refers to the development of students' self-belief and the courage to independently attempt and solve trigonometry problems (Kunhertanti & Santosa, 2018). Prior to the Think-Pair-Share (TPS) intervention, many students reported feeling intimidated by trigonometry. However, the structured opportunities provided by TPS to think individually, discuss in pairs, and then share with the larger group, gradually helped build their confidence.

Interview responses revealed that participants 1, 2, 4, 5, 6, 8, and 9 all believed the TPS strategy significantly contributed to improving their confidence in learning trigonometry. For instance, **Participant 1** shared, *"Before we started using Think-Pair-Share, I found trigonometry very*

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difficult. I used to get confused with sine, cosine, and tangent. But now, I feel more confident when solving problems." Similarly, **Participant 9** remarked, *"In the past, I would sit in class and not answer any questions because I was not sure of myself. But now, because of the Think-Pair-Share method, I have more courage to solve problems and even explain to others."*

Participant 5 explained, *"What helped me was that I had time to think first before discussing with my partner. This made me more confident because I had time to try solving the problem before talking."* Also Participant 8 stated, *"Now, I don't wait for the teacher to tell me the answer; I try solving it myself."* **Participant 6** added, *"TPS made me realize that even if I'm wrong, it's part of learning."* Meanwhile, **Participant 2** noted, *"Working with a partner helped me become less shy, and now I contribute more often., participant 4 mentioned that 'it gave me confidence when my answer matched my partner's''*

These responses collectively suggest that the Think-Pair-Share approach fostered a supportive and inclusive learning environment in which students felt safer to attempt problems, share their ideas, and view mistakes as an integral part of the learning journey. These conditions were instrumental in boosting their confidence in learning trigonometry.

Performance

The second sub-theme that emerged from the data was **students' performance**. In this context, performance refers to measurable improvements in test scores, assignment completion, and overall understanding of trigonometric concepts (Lamas, 2015). Following the implementation of the Think-Pair-Share (TPS) strategy, students consistently reported noticeable academic gains. Many highlighted improvements in their test results, better performance in homework, and a heightened interest in assessments. The opportunity to discuss and correct errors with peers fostered deeper conceptual understanding, which translated into improved performance in formal evaluations.

Participants 1, 3, 4, 5, 7, and 9 all attested to the positive impact of TPS on their performance. For instance, **Participant 1** shared, *"My test scores have improved, and I understand the steps better."* Similarly, **Participant 5** remarked, *"Honestly, when I pair with my classmates, we correct each other's mistakes, and that helps me learn better. My scores have gone up, and I am happy about that."*

Participant 3 noted, *"At first, I did not like trigonometry because it was too hard for me. But since we started using Think-Pair-Share, I feel more interested in the topic. My scores in class tests have increased because I now understand the steps better."* Likewise, **Participant 9** stated, *"My scores in assignment have improved because I now understand the process better."* **Participant 7** added, *"We practice so much during pairing, that test became easier."* **Participant 4** observed, *"With this strategy, I focus more and make fewer mistakes, which has helped me score higher."*

These responses underscore the effectiveness of the TPS strategy not only in promoting engagement and understanding but also in producing tangible improvements in academic outcomes among students learning trigonometry.

Reasoning

Another prominent sub-theme that emerged from the focus group discussions was students' mathematical reasoning. In this study, *reasoning* refers to students' ability to engage in logical thinking, analyze mathematical relationships, and explain the steps behind their solutions in trigonometry (NCTM, 2000; Stylianides, 2008). Reasoning goes beyond simply following procedures it involves making sense of concepts, identifying patterns, and justifying answers, all of which are crucial for mastering higher-order mathematical thinking.

Participants reported that the Think-Pair-Share (TPS) strategy encouraged them to think more deeply about how and why their solutions worked. Through the process of first thinking individually, then discussing with a partner, and finally sharing with the larger group, students were compelled to articulate their thoughts clearly and logically.

The responses of participants 1, 2, 3, and 7 emphasized the importance of peer discussion in enhancing understanding. For example,

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Participant 1 stated, *"Explaining to my partner helps me think better. I have to make sure my steps make sense."* Similarly, **Participant 2** shared, *"I try to justify my answers during TPS so I don't just guess."* **Participant 3** reflected, *"Sometimes I discover a new way to solve from our pair discussion."* Likewise, **Participant 7** noted, *"it make me think before jumping to answers."*

The evidence from the students' responses confirms that TPS is a powerful tool for nurturing mathematical reasoning. By requiring students to explain, justify, and sometimes defend their solutions during peer discussions, TPS helps build their confidence in critical thinking and their ability to approach problems from multiple perspectives.

Retention

The fourth sub-theme that emerged from the qualitative data was *retention*. In the context of this study, retention refers to students' ability to recall, store, and apply mathematical knowledge over time particularly the key concepts and procedures in trigonometry. Retention is a critical aspect of academic success, especially in mathematics, where cumulative understanding is essential for progression (Mayer, 2009).

Six participants (1, 2, 3, 5, 8, and 9) reported that the TPS strategy significantly improved their ability to retained, which in turn contributed to better performance in trigonometry. For instance, **Participant 3** shared, *"When I discuss with my group, I remember better during assignment."* Similarly, **Participant 2** remarked, *"The example I solved with friends stay longer in my head."*

Participant 5 reflected, *"Because we repeated it during TPS, it stuck in my memory."* Participant 8 noted, *"After discussing, I hardly forget the formula."* In the same vein, **Participant 9** said, *"I remember better when I say it out loud to someone."* **Participant 1** stated, *"Explaining to others helps me retain what I learned."*

These responses confirm that TPS not only improves understanding during the lesson but also enhances the durability of that learning.

Understanding

The fifth sub-theme that emerged from the findings is **understanding.** In this context, understanding refers to the development of a deeper and more meaningful grasp of trigonometric relationships and problem-solving strategies, moving learners beyond rote memorization (Fererde et al., 2024). Through the Think-Pair-Share (TPS) strategy, students had the opportunity to explain mathematical concepts to peers and listen to diverse interpretations. This process allowed them to explore multiple approaches to a single problem, which improved their conceptual clarity and made knowledge more retainable and transferable. Research has shown that explanatory dialogue and peer teaching are effective in fostering robust mathematical understanding (Hatt, 2024).

The perspectives of participants 1, 2, 3, 6, and 9 emphasized that the TPS strategy improved their understanding of trigonometry. For example, **Participant 3** stated, *"Before, the teacher just explained everything on the board, and we only listened. But now, we get to talk about the topic with our partners, and that helps me understand better."* Likewise, **Participant 2** remarked, *"Yes, it helped me a lot. Before, I didn't understand how to apply sine and cosine in solving problems, but discussing with my partner made it clearer."*

Participant 6 commented, *"I finally understood how sine and cosine are connected after talking to friends."* Similarly, **Participant 9** added, *"Now I know why formulas work, not just how to use them."* Finally, **Participant 1** reflected, *"Explaining steps to my partner helped me understand the problems better than just memorizing."*

These statements suggest that the TPS strategy provided a platform for students to process and internalize mathematical content more effectively. The shift from passive listening to active dialogue played a critical role in helping learners develop meaningful and lasting understanding of trigonometric concepts.

Table 21: Code of Students views on effects think pair share strategy on their academic achievement in trigonometry

Views	Interview Participant	Total

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	1	2	3	4	5	6	7	8	9	
Confidence	✓	✓		✓	✓	✓		✓	✓	7
Performance	✓		✓	✓	✓		✓		✓	6
Reasoning	✓	✓	✓				✓			4
Retention	✓	✓	✓		✓			✓	✓	6
Understanding	✓	✓				✓	✓		✓	5
Total	5	4	3	2	3	2	3	2	4	28

Source: Fieldwork, 2024

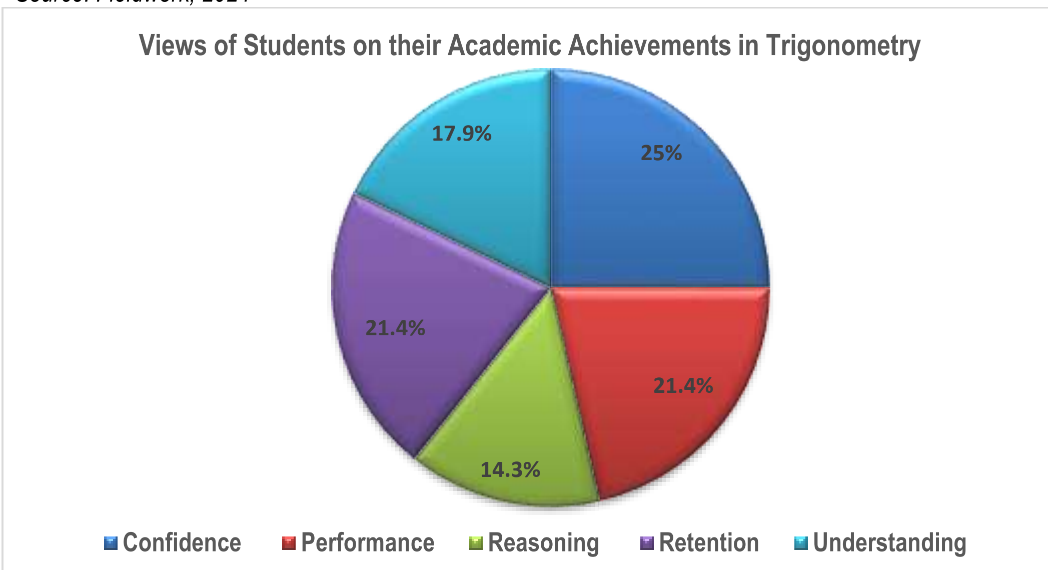

Figure 5: *Chart of Students' views on their academic achievement in Trigonometry: Source: Fieldwork, 2025*

Figure 5 illustrates students' perceptions of their academic achievement during trigonometry lessons delivered through the Think-Pair-Share (TPS) strategy. Analysis of Table 15 and figure 1 on the qualitative focus group data revealed strong support for the effectiveness of the TPS strategy in enhancing students' academic achievement in trigonometry. Thematic coding of the qualitative responses generated five dominant sub-themes. A total of 7 **responses (25%)** indicated that TPS improved their confidence. Additionally, 6 **responses (21.4%)** pointed to the improvement in their test and performance as a result of the TPS. Another 4 **responses (14.3%)** showed that students gained confidence in answering questions, particularly due to the supportive nature of the pair and share stages. Also, 6 **responses (21.4%)** referenced the retention *of formulae and steps* and 5 **responses (17.9%) illustrated** *peer support in understanding.* These findings collectively demonstrate that TPS improved students' achievement in trigonometry.

DISCUSSION OF THE FINDINGS

This study investigated the impact of the Think-Pair-Share (TPS) strategy on academic achievement, in trigonometry among senior secondary school students in Bauchi Education Zone. A mixed-methods approach was employed, combining quantitative data from pretest-posttest control group design and qualitative data. The findings are either in line with or in disagreement with several studies identified in the literature and discussed in the study.

Findings from **Research Question One** and the test of the corresponding null hypothesis revealed a statistically significant difference in the mean

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academic achievement scores between students taught trigonometry using the Think-Pair-Share (TPS) strategy and those taught using the traditional lecture method. Specifically, students exposed to the TPS instructional strategy performed significantly better than their counterparts in the control group. This result demonstrates the effectiveness of the TPS model in enhancing students' academic achievement in mathematics, particularly in the topic of trigonometry.

This finding aligns with a growing body of literature that supports the effectiveness of TPS learning strategies in mathematics classrooms. Studies by Badru (2025), Haakachima and Lunjebe (2019), Akanmu (2019), and Alabi and Rasheed (2019) found that the TPS strategy improved students' academic performance across various mathematics topics. Similarly, Popoola and Olofinlae (2023), Okafor and Nzomiwu (2021), and Nwankwo and Nnamani (2025) reported that TPS promotes greater understanding, engagement, and improved test scores. These studies, carried out in different geopolitical and educational contexts, provide strong empirical support for the findings of the present research.

Complementing the quantitative data, results from the **interview** provided rich insights into students' experiences with the TPS strategy. Five core sub-themes emerged: **confidence, performance, reasoning, understanding, and retention.** The results from the figure 1, which also represent the frequency of qualitative responses, give a clear picture of how students experienced these lessons. A remarkable 25% of students reported increased **confidence** in solving trigonometric problems. This was followed by **performance** and **retention** at 21.4% and 21.4% each, while **understanding** stood at 17.9%, and **reasoning** at 14.3%. These percentages reflect not just numerical values but real shifts in how students perceived and approached mathematics. One student shared during the focus group discussion: *"What helped me was that I had time to think first before discussing with my partner. This made me more confident because I had time to try solving the problem before talking."* This simple reflection captures the core strength of TPS it gave students ownership of the learning process and allowed them to build their ideas before presenting them, reducing fear and increasing participation.

These findings are supported by several studies. For example, Sumekto (2018) found that TPS helped students become more expressive and confident through structured peer interaction. Similarly, Thomas (2023) reported that TPS encouraged deeper mathematical reasoning and reflection, leading to better academic outcomes. In the Nigerian context, Mohammed and Sani Yar'adua (2023) observed a significant improvement in students' achievement in algebra when TPS was used, attributing it to the confidence students gained from discussing with peers. Likewise, Ibe, Ezeliora, and Okafor (2024) confirmed that peer-learning strategies like TPS positively influenced students' performance in science-related subjects.

The 21.4% and 21.4% response rate for both performance and retention shows that students not only performed better in tests and assignments but were also able to remember what they had learned more effectively. The pairing and sharing activities enabled them to revisit and reinforce concepts, making learning more durable. This aligns with findings from Tahir, Basri, and Firdaus (2019), who noted that repeated peer discussion in TPS helped improve memory retention and accuracy in problem-solving. Also, Niyibizi et al. (2024) highlighted how Rwandan students retained more information and performed better academically after experiencing TPS-based instruction.

Although **reasoning** had the lowest response (14.3%), it is still a promising outcome. It shows that while many students could follow procedures and solve problems, more scaffolding may be needed to help them think critically and logically. This resonates with Bruner's (1966) theory, which emphasizes that learners construct new ideas based on current and past knowledge something that takes time and requires consistent opportunities to reflect and apply. The fact that more than half of the students recognized growth in their reasoning suggests that TPS is already

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laying the foundation for higher-order thinking skills.

The interview responses further strengthened these findings. Students explained how they could clarify their doubts, check their understanding, and even correct their mistakes during the "pair" phase. They appreciated being given the space to try, fail, and try again in a safe and respectful environment. This is in line with the views of Ismail, Bungsu, and Shahrill (2023), who reported that TPS enhanced collaborative learning, creativity, and academic performance in technical education settings. This concluded that both the percentages and students' voices reveal a consistent and positive impact of TPS on academic achievement.

CONCLUSION

Based on the findings and discussions, the following conclusions were made:

1. Think Pair Share Strategy was found to be effective in improving senior secondary school students' academic achievement in Trigonometry.
2. The individual interview conducted disclosed that Think Pair Share Strategy enhanced students' academic achievement in Trigonometry

RECOMMENDATIONS FROM THE STUDY

In view of the result of the data analyzed/discussed and review of related literature, the following recommendations were made:

1. Mathematics teachers at the senior secondary level should be encouraged to adopt the TPS strategy as a regular instructional approach to enhance engagement and understanding in trigonometry and similar abstract topics.
2. In-service training programs should include modules on collaborative learning strategies, particularly Think Pair Share, to equip teachers with practical implementation skills.
3. Curriculum developers should incorporate Think Pair Share and other cooperative learning strategies as recommended methodologies for teaching mathematics in the senior secondary school curriculum.

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