



**ENHANCING SECONDARY SCHOOL STUDENTS' KNOWLEDGE RETENTION
IN MATHEMATICS USING THINK-PAIR-SHARE INSTRUCTIONAL STRATEGY
IN MATHEMATICS IN ONITSHA EDUCATION ZONE, ANAMBRA STATE**

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Abstract

This study investigated effect of Think-Pair-Share instructional strategy on students' knowledge retention in circle geometry in Onitsha Education Zone of Anambra State. The study was guided by two research questions and three null hypotheses were formulated and tested at 0.05 level of significance. The study adopted a quasi-experimental research design, specifically, the pre-test, post-test non-equivalent control group design. The population of the study comprised 5,056 senior secondary two (SS2) students offering Mathematics in State Government-owned secondary schools in Onitsha education zone of Anambra state. A sample of 80 senior secondary school two (SS2) Mathematics Students selected using multi-stage sampling approach was used for the study. The instrument for data collection was the Mathematics Retention Test (MRT) which was validated by three experts and tested for reliability using Kuder-Richardson (KR-20) formula which yielded a reliability index of 0.85. Data collected were analysed using mean, standard deviation and analysis of covariance (ANCOVA). The findings of the study revealed among others that there was a significant difference between the mean retention scores of students taught circle geometry using Think-Pair-Share and those taught using Direct Instruction method in favour of the experimental group. In conclusion, students taught circle geometry using the Think-Pair-Share (TPS) instructional strategy achieved higher mean scores in retention compared to those taught using the Direct Instruction Method. Based on the findings, it was recommended, among others, that mathematics teachers should incorporate TPS as a primary instructional strategy, particularly, when teaching complex geometric concepts and also workshops and training should be organized for mathematics teachers to enhance their pedagogical skills in implementing TPS effectively.

Key words: Circle Geometry, Mathematics, Quasi-Experimental, Retention, Think Pair Share

Introduction

Science is a structured and systematic approach to acquiring and organizing knowledge through observation, experimentation, and critical analysis. Its primary goal is to explain natural phenomena, uncover fundamental principles, and apply discoveries to address real-world challenges. Disciplines such as mathematics, chemistry, biology, and physics all contribute to deepening our understanding of the universe and propelling technological progress. Among these, mathematics plays a crucial role by offering the tools for precision,



logical reasoning, and quantitative analysis that underpin scientific inquiry. Mathematics focuses on abstract thinking, problem-solving processes, and logical reasoning, all of which are vital for addressing human challenges. According to Ahmad (2016), mathematics involves logical thinking, forming and testing hypotheses, interpreting patterns, and making justified conclusions and inferences. The application of mathematics spans numerous fields, including science, technology, commerce, agriculture, and healthcare. Martin (2024) further stated that knowledge of mathematics is the essential ingredient that adds value and structure to all other disciplines. In Nigeria, its significance is evident in the educational system, where mathematics is a compulsory subject that students must pass at credit level to gain admission into higher institutions. Surya (2017) emphasizes that the goals of learning mathematics in school include training students to think critically and logically, to draw valid conclusions, and to solve problems efficiently. Mathematics also empowers learners to communicate effectively using various forms such as writing, speech, graphs, diagrams, and maps. Hasanah and Surya (2017) further assert that all students, beginning from elementary school, should be equipped with mathematical knowledge to foster logical, analytical, systematic, critical, creative, and collaborative thinking skills—particularly within the context of learning geometry.

Geometry is a branch of mathematics concerned with the study of shapes, their properties, and the spatial relationships between them. As a fundamental component of the mathematics curriculum, geometry plays a vital role in developing students' spatial awareness and enhancing their geometric reasoning abilities. Through the study of geometry, students cultivate logical thinking and strengthen their mathematical reasoning skills, making geometry an essential tool for intellectual development. Geometric reasoning involves understanding relationships within and between geometric figures, enabling students to think analytically and visualize abstract concepts. Consequently, learners are expected to engage in various reasoning tasks and develop specific geometric thinking skills that are crucial for more advanced mathematical learning. The field of geometry encompasses several branches, including Euclidean, Non-Euclidean, Analytic, Projective, Differential Geometry, and Topology. Among these, Euclidean geometry is the most commonly taught in schools. It focuses on the properties of flat, two-dimensional shapes and explores the relationships between points, lines, angles, and surfaces within a plane. Circle geometry, for example, falls under the domain of Euclidean geometry, as it deals with circular figures and their properties in a flat, two-dimensional space.



In geometry, a circle is defined as a two-dimensional (2D) figure comprising all points equidistant from a fixed point known as the center (Haylock, 2018). As a flat geometric shape, the circle holds special significance due to its wide range of applications in everyday life (Mollakuqe et al., 2021; Arnigo et al., 2018). The study of circles typically begins with foundational concepts such as radius, diameter, area, and key properties, before progressing to more advanced applications. This progression highlights the need for students to develop a solid understanding of basic definitions and relationships before engaging in higher-order reasoning tasks involving circle geometry (Arnigo et al., 2018). Despite its importance, circle geometry remains a challenging topic for many students. One major factor contributing to these difficulties is the abstract nature of the theorems involved, combined with the frequent use of teacher-centered instructional methods that may limit student engagement and conceptual understanding. Reports from the West African Examinations Council (WAEC) between 2015 and 2018 consistently identified circle geometry as one of the most difficult areas for students in mathematics. Durojaiye (2016) also noted that students often struggled with questions involving circle geometry, particularly when such questions were compulsory, leading many to avoid them when given the option.

Several studies (Ajani & Olabode, 2018; Durojaiye, 2016; OnwuIji, Omenka & Akpan, 2018; Timayi, Bolaji & Kajuru, 2015; Unodiaku, 2018) have consistently highlighted the difficulties students encounter in learning this topic. Mastery of circle geometry is essential for developing deductive reasoning and the ability to visually identify and interpret geometric properties and theorems. However, despite the elegance and foundational nature of circle theorems, students often struggle with memorizing and applying them effectively (Hissan & Ntow, 2021). Even students who are familiar with the core mathematics curriculum often perceive circle geometry as abstract and technically demanding. A common instructional challenge lies in the way teachers introduce circle theorems. Ntow and Hissan (2021) observed that many teachers do not adequately present these concepts in a gradual and comprehensible manner, often rushing through explanations before students fully grasp the underlying principles. This hinders students' ability to connect conceptual understanding with practical problem-solving, further compounding the difficulties associated with learning circle geometry.

In many mathematics classrooms, teachers frequently rely on teacher-centered instructional approaches, particularly direct instruction or the traditional lecture method. This



approach places the teacher at the center of the learning process, delivering content while students remain largely passive recipients. While direct instruction can be effective for managing large classes and ensuring timely coverage of the syllabus, it often leads to disengagement and makes learning less meaningful for students. Such teacher-dominated methods have been criticized for their limited effectiveness in promoting deep understanding and active learning (Falebita, 2019). Given these limitations, there is a growing need to adopt student-centered instructional strategies that foster engagement, collaboration, and critical thinking, especially in challenging topics like circle geometry. One such approach is the Think-Pair-Share strategy, a cooperative learning technique that has gained recognition for its ability to improve mathematics learning outcomes. This strategy encourages students to think independently, discuss ideas with peers, and share insights with the class, thereby enhancing conceptual understanding and promoting social interaction in the learning environment.

Think-Pair-Share (TPS) is a cooperative discussion strategy originally developed by Frank Lyman and colleagues in Maryland. The name reflects its three distinct phases think, pair, and share each of which guides student participation at various stages of the learning process. As a collaborative instructional technique, TPS encourages students to first reflect individually on a question or problem, then discuss their thoughts with a partner, and finally share their ideas with the larger group or class. This approach actively engages students in processing content, improves their comprehension, and fosters deeper understanding through peer interaction. By encouraging students to articulate their ideas and listen to others, TPS promotes critical thinking, maximizes participation, and ensures that all learners are involved in the learning experience. According to Farrajallah (2017), implementing the TPS strategy transforms the classroom into a dynamic environment scientific, cultural, and even entertaining making learning more appealing and memorable for students.

The method also enhances students' ability to recall information, as peer discussions help reinforce concepts before they are shared with the entire class. TPS not only allows students to solve problems collaboratively but also enables them to support one another using their individual strengths. Sejani (2016) highlighted that TPS significantly improves students' problem-solving skills and mathematics learning outcomes. Similarly, Napitupulu and Surya (2017) emphasized that TPS increases students' interest in mathematics, fosters active participation, and promotes social interaction and teamwork. Ultimately, this strategy contributes to improved retention and a more engaging, learner-centered classroom environment.



In educational and psychological contexts, knowledge retention refers to an individual's ability to recall and effectively utilize information previously learned and stored in memory. Muokwe (2021) defines retention as the capacity of students to remember a concept after a certain period has passed. Retention plays a crucial role in supporting effective thinking and problem-solving. It is not enough for students to be taught mathematical concepts, particularly in geometry; it is equally important that they retain this knowledge over time. Research has shown that instructional methods can significantly influence learners' retention levels. For instance, Abdullahi (2015) emphasized that self-directed learning enhances both the retention of information and the development of positive attitudes toward science and technology. Retention serves as a mental process that preserves learned material, enabling individuals to retrieve and apply it when needed.

Through sensation and perception, the mind acquires knowledge, which is then stored as mental images. These images must be preserved and recalled when similar situations arise, facilitating memorization and understanding. For this reason, mathematics—particularly abstract topics like circle geometry—should be taught using methods that engage the learner's subconscious, thereby enhancing recall. Strategies such as Think-Pair-Share allow both high- and low-ability learners to collaborate, discuss, and reinforce understanding. This not only aids comprehension but also improves retention by encouraging peer explanation and active participation. The ability to retain information—whether in short-term or long-term memory—can be influenced by several factors, including the instructional method used, the learning environment, and individual differences such as gender. Therefore, adopting effective, student-centered strategies is essential for ensuring that mathematical concepts are not only learned but retained meaningfully over time by students irrespective of gender.

Gender refers to the social and cultural constructs that define the roles, behaviors, expectations, and attributes society typically assigns to individuals based on their perceived sex. Kolawole (2019) describes gender as a socio-cultural concept that attributes specific roles and qualities to individuals identified as male or female. Unlike sex, which is biologically determined, gender is shaped by societal norms and expectations. It encompasses how individuals identify themselves and how they are perceived and treated within social institutions based on their gender expression. According to Yang and Chen (2013), among the various human factors that influence learning, spatial ability and gender differences are particularly significant in the context of geometry. These differences can impact students' performance, as males and females may respond differently to various instructional



environments and learning tasks in geometry. Battista (2013) further suggests that a balance between spatial and logical reasoning skills contributes to overall success in geometric problem-solving. Bal (2014) also highlights attitude as a key predictor of success in geometry, noting that gender can influence students' achievement due to the predominance of cultural expectations over biological differences. This underscores the broader concern in mathematics education about gender disparities, especially the persistent underrepresentation of females in advanced levels of mathematics, physical sciences, and engineering (Asante, 2020). Given these considerations, it becomes essential to examine whether gender influences students' retention of concepts in circle geometry when taught using the Think-Pair-Share (TPS) instructional strategy. This is particularly relevant in light of findings from the National Business and Technical Examinations Board (NABTEB) Chief Examiners' Mathematics Report (2012), which identified geometry as a challenging area for many students. Understanding gender-related dynamics in learning and retention can help educators adopt more inclusive strategies that address diverse learning needs and promote equity in mathematics education.

This concern is further resonated in the West African Examinations Council (WAEC) Chief Examiners' Reports (2019–2023), which consistently highlighted students' weaknesses in understanding and applying concepts in circle geometry. These persistent challenges have been largely attributed to the use of inefficient and ineffective teaching methods that fail to engage learners or promote deep understanding and long-term retention. A feasible approach to addressing this issue is to discover alternative instructional strategies through empirical research, identifying methods that can produce more effective learning outcomes. To improve students' retention and performance in circle geometry, it becomes essential to employ learner-centered strategies, such as the Think-Pair-Share (TPS) instructional method, which has shown promise in enhancing comprehension, engagement, and retention. This consideration forms the basis of the present study, which seeks to investigate the effect of the Think-Pair-Share instructional strategy on enhancing secondary school students' knowledge retention in mathematics in Onitsha Education Zone, Anambra State. Specifically, the study aims to achieve the following objectives:

1. Mean retention scores of students taught circle geometry using Think-Pair-share Instructional Strategy and those taught using Direct Instruction Method,
2. Mean retention scores of male and female students taught circle geometry using Think-Pair-Share Instructional Strategy.



3. Interaction effect of instructional strategies and gender on students' retention in circle geometry.

Research Questions

1. What are the mean retention scores of students taught circle geometry using Think-Pair-Share instructional strategy and those taught using direct instruction method?
2. What are the mean retention scores of male and female students taught circle geometry using Think-Pair-Share instructional strategy?

Research Hypotheses

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

1. There is no significant difference between the retention scores of students taught circle geometry using Think-Pair-Share instructional strategy and those taught using direct instruction method.
2. There is no significant difference in the mean retention scores of male and female students taught circle geometry using Think-Pair-Share instructional strategy.
3. There is no significant interaction effect of instructional strategies and gender on the mean retention scores of students in circle geometry.

Methods

The study adopted quasi-experimental specifically, the pretest, posttest nonrandomized control group research design. The study was carried out in Onitsha Education Zone of Anambra State. The population of the study comprised of 5056 SS 2 students from the 32 public secondary schools. The sample of the study comprised of 80 (41 males and 39 females) SS 2 students drawn from two out of 20 co-educational secondary schools in Onitsha Education Zone of Anambra State using two-stage sampling techniques involving simple random and purposive sampling techniques. The instrument that was used for data collection was Mathematics Achievement Test (MAT). The MAT was adopted from WASSCE past questions. The MAT is designed into two sections, A and B. Section A seeks personal information on the students while Section B contains 25 multiple - choice questions on circle geometry. Each question has four options a, b, c and d and students are required to pick the correct option.

The instrument was validated by three experts and tested for reliability using Kuder-Richardson formula 20 (KR-20) which yielded a reliability index of 0.85. The treatment was done in two phases; in the first phase, the teacher in the experimental group was briefed by the researcher before the treatment process on how to effectively use Think-Pair-Instructional



Strategy, while the teacher in control group was given topics with the lesson plans and then asked to teach the students as usual. In the second phase, teaching commenced on the next mathematics class by their regular teachers for 4 weeks of teaching on circle geometry. After the teaching, posttest was administered to the subjects by the mathematics teachers. Thirty minutes was allowed for the test. The test was marked by the teachers. Scores were collated, collected by the teachers and handed over to the researcher. The retention test was administered two weeks after the post test. The aim of the retention test was to find out if there was any retention in knowledge that might have arisen from the treatment. The data obtained from each group using the Mathematics Retention Test (MRT) was analyzed using mean and standard deviation to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance. The choice of ANCOVA for testing the research hypotheses was based on its ability to control the effect of pretest on posttest. The decision rule for the hypotheses was that whenever the probability value (p-value) is less than or equal to the significant value of 0.05, the null hypothesis is rejected, otherwise the null hypothesis is not rejected.

Results

Table 1: Mean and standard deviation on retention scores of students taught circle geometry using TPS and DIM

Method	N	Post-test		Retention		Mean Gain
		Mean	SD	Mean	SD	
TPS	41	15.2	3.855	17.2	3.607	2
DIM	39	14.7	4.005	15.4	3.732	0.7
Mean Diff.		0.5		1.8		1.3

Table 1 showed that students taught circle geometry with the TPS method had a post-test mean score of 15.2 and a retention mean score of 17.2, resulting in a mean gain of 2. Students taught with the DIM method had a post-test mean score of 14.7 and a retention mean score of 15.4, with a mean gain of 0.7. The mean gain difference between the two methods was 1.3, which suggest that TPS was more effective in enhancing students' retention scores compared to DIM method, as indicated by a greater mean gain. This implies that the TPS method enhances students' long-term retention of knowledge in circle geometry.



Table 2: Mean retention scores and standard deviation on retention scores of male and female students taught circle geometry using TPS and DIM

Method	Gender	N	Post-test		Retention		Mean Gain
			Mean	SD	Mean	SD	
TPS	Male	24	14.1	3.348	16.64	3.688	2.54
	Female	17	15.9	4.287	16.31	3.849	0.41
Mean Diff.			-1.8		0.33		2.13
DIM	Male	17	15.06	3.47	16.0	3.76	0.94
	Female	22	15.64	3.98	16.6	3.34	0.96
Mean Diff.			-0.58		-0.6		-0.02

Table 2 revealed the retention mean and standard deviation scores, for male and female students taught circle geometry using the Think-Pair-Share (TPS) method and the Direct Instruction Method (DIM). It was observed that male students taught using TPS method had a posttest and retention mean scores of 14.1 and 16.64 respectively resulting in a mean gain of 2.54, while the female students had posttest and retention mean scores of 15.9 and 16.31 respectively with a mean gain of 0.41. The mean gain difference of 2.13 indicates that the TPS method was more effective in enhancing retention for male students than for females. On the other hand, male students taught using DIM, achieved retention mean scores of 15.06 and 16.0 respectively, resulting in a mean gain of 0.94, while female students showed posttest and retention mean scores of 15.64 and 16.6 respectively with a mean gain of 0.96. The mean gain difference of -0.02 suggests that DIM was equally effective for both genders in terms of retention. In comparison, the TPS method improves greater retention for male students than female students compared to DIM method.

Table 3: Summary of Analysis of Covariance of retention scores of secondary school students taught circle geometry using TPS and those taught using DIM

Sources of Variation	Sum of Squares	Df	Mean Square	F	P-Value	Decision
Corrected Model	695.279 ^a	4	173.820	31.046	.000	
Intercept	739.828	1	739.828	132.141	.000	
Post-test	610.398	1	610.398	109.023	.000	
Method	69.122	1	69.122	12.346	.001	Sig.
Error	419.909	75	5.599			
Total	22403.000	80				



Corrected Total 1115.187 79

Table 3 revealed the analysis of covariance (ANCOVA) results which examined the effect of instructional strategies on the students’ retention while controlling for post-test scores. The overall corrected model was significant, $F(4, 75) = 31.046, p < .001$. However, after controlling for post-test scores, there was significant main effect of method on the students’ achievement in circle geometry $F(1, 75) = 12.346, P = .001$. Hence, $P < 0.05$, reject the null hypothesis. Thus, the mean retention scores of SS2 students’ taught circle geometry using Think-Pair-Share instructional strategy (TPS) and those taught using direct instruction method (DIM) differs significantly.

Table 4: Summary of Analysis of Covariance of retention scores of male and female students taught circle geometry using Think-Pair-Share instructional strategy.

Sources of Variation	Sum of Squares	Df	Mean Square	F	P-Value	Decision
Corrected Model	695.279 ^a	4	173.820	31.046	.000	
Intercept	739.828	1	739.828	132.141	.000	
Post-Test	610.398	1	610.398	109.023	.000	
Gender	12.684	1	12.684	2.265	.136	Not Sig.
Error	419.909	75	5.599			
Total	22403.000	80				
Corrected Total	1115.187	79				

Table 4 revealed the analysis of covariance (ANCOVA) results which examined the effect of gender on the students’ retention while controlling for post-test scores. The overall corrected model was significant, $F(4, 75) = 31.046, p < .001$. However, after controlling for post-test scores, there was no significant main effect of gender on students’ retention in circle geometry $F(1, 75) = 2.265, P = .136$. Hence, $P > 0.05$, the result fail to reject the null hypothesis. Therefore, there is no significant difference in the retention scores of male and female SS2 students taught circle geometry using Think-Pair-Share instructional strategy.

Table 5: Summary of Analysis of Covariance of interaction effect of the instructional strategies and gender on students’ retention scores in circle geometry.

Sources of Variation	Sum of Squares	Df	Mean Square	F	P-Value	Decision
Corrected Model	695.279 ^a	4	173.820	31.046	.000	
Intercept	739.828	1	739.828	132.141	.000	
Post-Test	610.398	1	610.398	109.023	.000	
Method * Gender	10.929	1	10.929	1.952	.166	Not Sig.

Error	419.909	75	5.599
Total	22403.000	80	
Corrected Total	1115.187	79	

The analysis of covariance (ANCOVA) results presented in Table 10 was conducted to examine the interaction effects of instructional strategies and gender on students' retention while controlling for post-test scores. The overall corrected model was significant, $F(4, 75) = 31.046$, $P < .001$. However, after controlling for post-test scores, there was no significant interaction effect between instructional strategies and gender, $F(1, 75) = 1.952$, $P = .166$. Since, $P > 0.05$, the result fail to reject the null hypothesis. Therefore, there is no significant interaction effect of the instructional strategies and gender on students' retention in circle geometry.

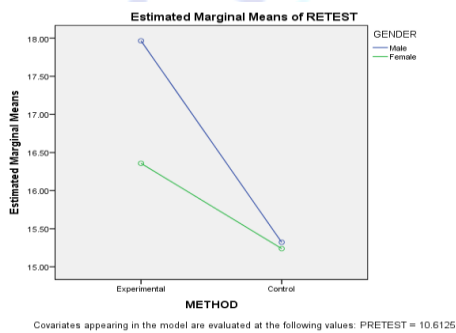


Fig. 4: Profile plots of interaction effect of gender and teaching method (TPS and DIM) on retention of students in circle geometry.

The profile plots on two teaching methods on male and female students' retention scores are slightly parallel to each other without intersection. Hence, there is no interaction effect of gender and teaching method on retention of students in circle geometry. The steeper decline in the blue line (males) compared to the green line (females) indicates a potential interaction effect between gender and teaching method. By implication, the effect of the two teaching methods on retention score of students in circle geometry does not depend on their gender.

Discussion

The finding of this study revealed that the mean retention score of students taught circle geometry in mathematics using think pair share has a higher mean gained than those taught with direct instruction method. The finding of this study resonates with that of Bassey (2023), whose study revealed that students taught with think-pair-share had a higher retention score than those with lecture method. Similarly, the finding of the study aligns with the study of Sunday, Afaha, Jimmy and Assan (2023) which showed that the mean retention scores of



students taught matter using Think Pair Share was higher than those who were taught using lecture method.

The corresponding hypothesis, revealed that TPS has a significant effect in enhancing the memory of students taught circle geometry than those taught using direct instruction method. The finding of this study indicates that the Think-Pair-Share (TPS) instructional strategy significantly enhances students' retention ability in circle geometry compared to the direct instruction method. The finding of this study aligns with the finding of Chianson, Kurumeh and Obida (2011), which revealed a significant effect on students' retention in circle geometry. In contrast, the finding of this study differ from that of Sao (2023) which showed that there is no statistically significant difference in the retention ability of students taught using the TPS strategy compared to those taught with the conventional method, suggesting that both strategies yield similar retention outcomes. Also, the finding of Akanmu (2019) showed that a significant difference existed in the retention ability of senior school students taught set theory in mathematics using think pair share and their counterpart in the control group and this showed that the use of think pair share had significantly improved students retention ability in mathematics.

The finding of this study showed that the male students has a higher mean gain in terms of retention of what was taught and learned than their female counterparts using TPS method. The findings are consistent with that of Okolocha and Nwaukwa (2020) whose study revealed that TPS has an equal effect on students' retention ability regardless of gender, suggesting that any observed differences are likely due to chance.

On testing the hypothesis, it was observed that there is no significant difference in the mean retention scores of male and female students taught circle geometry using TPS strategy implying that both gender has the same retention rate. This finding contradict the finding of Okolocha and Nwaukwa (2020) which showed that there is a significant difference between retention mean scores of students taught financial accounting with think pair share instructional strategy and those taught using conventional teaching method.

The finding of this study revealed that there was no significant interaction effect between the instructional strategies and gender on retention scores of students taught circle geometry. The finding of the study is supported by that of Sunday, Nyanko and Assan (2023), whose study revealed that there was no significant interaction on the influence of gender and teaching methods on students mean retention scores in matter in chemistry.



Recommendation

Based on the findings of the study, the following recommendations were made

- 1 Given the effectiveness of the TPS strategy in enhancing students' retention in circle geometry, mathematics teachers should incorporate TPS as a primary instructional method, particularly when teaching complex geometric concepts.
- 2 Since TPS was effective for both male and female students' retention, educators should adopt differentiated instructional strategies that leverage students' learning strengths. This could include combining TPS with other student-centered approaches to accommodate diverse learning needs.
- 3 Workshops and training programs should be organized for mathematics teachers to enhance their pedagogical skills in implementing TPS effectively.
- 4 Curriculum developers and policymakers should integrate TPS into the mathematics curriculum at various levels, ensuring that lesson plans and instructional materials are designed to facilitate collaborative learning and problem-solving in geometry.

References

- Abdullahi, M. S., Abubakar, A., Aliyu, R. L., and Umar, M. B. (2015). Empirical review on the determinants influencing firm performance in developing countries. *International journal of scientific and research publications*, 5(6), 1-10.
- Ahmad, S. Z. (2016). The Flipped Classroom Model to Develop Egyptian EFL Students' Listening Comprehension. *English language teaching*, 9(9), 166-178.
- Ajani, T. O., & Olabode, J. O. (2018). Influence of collaborative learning on students' achievement in Mathematics in Abeokuta south local government, Ogun state. *ABACUS (Mathematics Education Series)*, 43(1), 81-88.
- Arnigo, John Conray, Exzequel Lim, Mary Jane Manalo, Vincent Luigi Pacheco, Bea Secosana, Angelica Sy, and Levi Elipane. "Utilizing lesson study in teaching circles." *Advanced Science Letters* 24, no. 11 (2018): 7876-7879.
- Bal, R. (2017). Playing the indicator game: reflections on strategies to position an STS group in a multi-disciplinary environment. *Engaging Science, Technology, and Society*, 3, 41-52.
- Chen, X. (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001. *National Center for Education Statistics*.
- Falebita, D. E., Saviour, M. K., Jaiyeola, J. I., Ojo, O. A., & Adepelumi, A. A. (2019). Discrimination of Post-Stack Bright Spots Using Avo and Model-Based Inversion Technique, Coastal Swamp Niger Delta, Nigeria-A Case Study. *Petroleum & Coal*, 61(6).
- Farrajallah, A. E. K. (2017). The Impact of Employing the (Think-Pair-Share) Strategy to Gain Some Number Sense Skills and Mathematical Communication Skills Among Fifth Grade Students. *An-Najah University Journal for Research-B (Humanities)*, 31(9), 1627-1663.



- Hasanah, M., and Surya, E. (2017). Differences in the abilities of creative thinking and problem solving of students in Mathematics by using cooperative learning and learning of problem solving. *International Journal of Sciences: Basic and Applied Research (IJSBAR)*. 34, 1, 286-299.
- Haylock, D. (2024). *Mathematics explained for primary teachers*.
- Hissan, Y., & Ntow, F. D. (2021). An investigation into the effect of concept based instruction on senior high school students' geometric thinking and achievement in circle theorem. *International Journal of Research and Innovation in Social Science*. <https://www.rsisinternational.org/journalsLibrary>, 5, 52-60.
- Mollakuqe, V., Rexhepi, S., & Iseni, E. (2020). Incorporating Geogebra into teaching circle properties at high school level and it's comparison with the classical method of teaching. *International Electronic Journal of Mathematics Education*, 16(1), em0616.
- Muokwe, O. E. (2021). Effect of Jigsaw technique on the Academic Achievement and Detention of Secondary School students in Awka Educational Zone, Anambra State. Unpublished MSc project, Nnamdi Azikiwe University, Awka.
- Napitupulu, W. R., & Surya, E. Character Education Role In Learning Mathematics As Generation Formers Anticorruption.
- National Business and Technical Education Board (NABTEB) (2019). Chief Examiners Report on Mathematics. Benin City, Edo state, Nigeria.
- OnwuIji, C., Omenka, J. E. and Akpan, E. M. (2018). Effect of multimedia aided instruction on junior secondary one students' interest in geometry in Uyo metropolis, Akwalbom state, Nigeria. *ABACUS (Mathematics Education Series)*, 43(1), 101-109.
- Timayi, J. M., Bolaji, C., & Kajuru, Y. K. (2015). Effects of Jigsaw IV cooperative learning strategy (J4CLS) on academic performance of secondary school students in geometry. *International Journal of Mathematics Trends and Technology-IJMTT*, 28.
- Unodiaku, S. S. (2018). Teaching geometrical and mensuration proofs with origami-based instrumental model approach among seniorsecondary school students in Enugu state. *ABACUS (Mathematics Education Series)*, 43(1), 14-24.
- West African Examination Council (WAEC) (2018), (2019), (2020),(2021),(2022), (2023). Chief Examiners Report on strength and weakness of Mathematics on circle geometry Lagos: Nigeria.