Effect of Culturo-Techno-Contextual Approach on Students' Performance and Retention in Trigonometry in Rivers East Senatorial District, Rivers State, Nigeria

[*1]Nweke, N. O., [2]Adolphus, T., & [3]Naade N. B

[1,2,3]Department of Science Education, Faculty of Education, Rivers State University, Nkpolu Oroworukwo, Port-Harcourt, Nigeria

***Corresponding Author**

DOI: https://doi.org/10.51584/IJRIAS.2026.11080031

Received: 16 August 2026; Accepted: 21 August 2026; Published: 01 September 2026

ABSTRACT

This study investigated the effect of the Culturo-Techno-Contextual Approach (CTCA) on students' performance and retention in trigonometry among senior secondary school students in Rivers East Senatorial District, Nigeria. The study adopted a quasi-experimental research design involving pretest, posttest, and post-posttest non-equivalent control groups. The population comprised 38,971 students offering mathematics in public Senior Secondary School Two (SS2) schools within Rivers East Senatorial District. A sample of 334 Senior Secondary School Two (SS2) students drawn from four public secondary schools participated in the study through a multistage sampling procedure. The instruments used for data collection were the Basic Trigonometry Test (BTT), Trigonometry Performance Test (TPT), and Trigonometry Retention Test (TRT). The reliability coefficients were established using the test–retest method, yielding 0.98 for BTT and 0.93 for TPT. Students in the experimental group were taught using the Culturo-Techno-Contextual Approach, while those in the control group were taught using the Cooperative Learning Method. Mean and standard deviation were used to answer the research questions. In contrast, Analysis of Covariance (ANCOVA) and Independent Samples t-test were used to test the hypotheses at the 0.05 level of significance. The findings revealed that students taught using CTCA performed significantly better and retained trigonometric concepts more effectively than those taught using the Cooperative Learning Method. The study concluded that CTCA is an effective instructional approach for improving students' performance and retention in trigonometry. It was therefore recommended that mathematics teachers adopt CTCA in teaching trigonometry and other abstract mathematical concepts in secondary schools.

Keywords: Culturo-Techno-Contextual Approach, trigonometry, performance, retention

INTRODUCTION

Culturo-Techno-Contextual Approach (CTCA) is an innovative instructional framework that combines learners' cultural backgrounds, technological tools, and contextual, real-world circumstances with classroom teaching and learning. The approach was developed to shift learning away from rote memorization and toward meaningful understanding by linking academic ideas to students' immediate surroundings and lived experiences (Okebukola, 2020). Empirical research indicates that CTCA improves students' engagement, conceptual understanding, academic achievement, and retention across STEM-related fields (Akintoye et al., 2024; Adam et al., 2024). Its success is attributed to its learner-focused orientation, use of active learning practices, and ability to make abstract concepts more usable and personally relevant to students. In mathematics education, especially in conceptually challenging topics such as trigonometry, instructional strategies that support meaningful understanding and long-term retention are increasingly important, partly because persistent findings point to poor student achievement and inadequate conceptual understanding. Although CTCA has shown encouraging results, relatively few studies have investigated its effectiveness in

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

mathematics education, particularly in enhancing students' achievement and retention in trigonometry among secondary school students in Nigeria.

Trigonometry continues to be one of the most conceptually demanding areas in secondary school mathematics because of its abstract character and symbolic representations. The subject examines relationships among the sides and angles of triangles and has broad applications in disciplines such as engineering, architecture, navigation, astronomy, and physics (Bekene & Machaba, 2022). Beyond its practical importance, trigonometry strengthens learners' logical reasoning, spatial visualization, and problem-solving abilities. However, many students struggle with trigonometric concepts because classroom instruction often centers on formulas, procedures, and symbolic operations without establishing adequate links to real-life experiences (Dhungana et al., 2023). Research shows that learners often struggle with topics such as trigonometric ratios, identities, and angles of elevation and depression, largely because of weak conceptual understanding and limited visualization skills (Odor et al., 2023). As a result, many students rely on rote memorization, which reduces their capacity to use knowledge meaningfully and leads to poor academic outcomes.

Performance in external assessments further corroborates students' challenges in trigonometry. Findings reported by the West African Examinations Council between 2021 and 2023 consistently show low achievement in trigonometry-related questions among secondary school students in Nigeria. Chief Examiners' reports repeatedly cite weaknesses in areas such as trigonometric identities, the use of sine and cosine rules, and angles of elevation and depression, attributing these difficulties largely to ineffective teaching approaches and insufficient understanding of the underlying concepts (Tyata et al., 2021). Scholars have also maintained that the predominance of teacher-centered instructional practices in mathematics classrooms contributes substantially to these ongoing learning difficulties (Folake & Ibidiran, 2021). In many classrooms, students are trained to apply formulas mechanically without understanding the meaning or practical value of the concepts taught. Such instructional approaches not only weaken students' academic performance but also reduce their ability to retain learned concepts over time.

Empirical evidence continues to support the effectiveness of CTCA in improving learning outcomes across STEM disciplines. Akintoye et al. (2024) reported that students exposed to CTCA demonstrated significantly higher achievement and engagement in physics compared to those taught using conventional methods. Similarly, Adam et al. (2024) found that CTCA enhanced students' retention and conceptual understanding in biology by linking instruction to familiar experiences and technological activities. A systematic review conducted by Oladejo et al. (2025) further concluded that CTCA consistently promotes meaningful learning, improves academic performance, and strengthens retention across different subject areas. Despite these promising findings, there remains limited empirical evidence regarding the application of CTCA in the teaching and learning of trigonometry in Nigerian secondary schools. Given the persistent poor performance and weak retention associated with trigonometry, there is therefore a need to investigate the effect of the Culturo-Techno-Contextual Approach on students' performance and retention in trigonometry among senior secondary school students in Rivers East Senatorial District, Nigeria.

Retention is central to meaningful learning and a key measure of instructional effectiveness in mathematics education. It reflects students' ability to recall and apply previously taught concepts after instruction. According to David Ausubel, meaningful learning occurs when new knowledge integrates with learners' existing cognitive structures, supporting deeper understanding and sustained retention (Ausubel, 1962). Likewise, Baddeley (2020) notes that retention involves retrieving information from memory systems when needed. Evidence indicates that students retain mathematical concepts more effectively when they actively participate in learning activities and when instruction is tied to familiar experiences and practical applications (Oladejo et al., 2022). However, traditional instructional methods that emphasize memorization and passive learning often lead to poor retention, so students tend to forget concepts shortly after examinations. Research also shows that students retain concepts better when they are meaningfully and interactively engaged in learning rather than relying on rote memorization (Wilcox et al., 2020). In trigonometry, weak retention is a significant problem because students must accurately recall and apply formulas, identities, and problem-solving procedures in unfamiliar contexts. This points to the need for instructional approaches that enhance both students' performance and retention.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

The growing focus on learner-centered instructional approaches in mathematics education has helped to spur increasing interest in culturally responsive and technology-supported teaching strategies. Constructivist approaches, including inquiry-based learning, problem-based learning, and cooperative learning, are designed to promote active engagement, collaboration, and a clear appreciation of context (Gómez-Chacón et al., 2023). Although these approaches have been linked to gains in students' achievement, they often do not sufficiently integrate learners' cultural backgrounds and technological experiences into everyday classroom instruction (Okebukola, 2020). In many African classrooms, mathematics is still presented as an abstract subject that is detached from students' everyday lives, thereby limiting both learners' interest and their understanding. CTCA addresses this gap by embedding cultural relevance, technological scaffolding, and contextual problem-solving within the learning process. The cultural component connects instruction to learners' indigenous experiences and local practices; the technological component employs digital tools such as simulations and animations to enhance visualization; and the contextual component situates learning in real-world scenarios that are meaningful to students (Oladejo et al., 2025). Collectively, these elements may offer a strong instructional framework for improving students' understanding and long-term retention of trigonometric concepts.

Empirical evidence continues to support the effectiveness of CTCA in enhancing learning outcomes across STEM disciplines. Akintoye et al. (2024) reported that students taught through CTCA attained significantly higher levels of achievement and engagement in physics than students taught using conventional methods. Likewise, Adam et al. (2024) found that CTCA improved students' retention and conceptual understanding in biology by connecting instruction to familiar experiences and technology-related activities. A systematic review by Oladejo et al. (2025) further concluded that CTCA consistently promotes meaningful learning, strengthens academic performance, and improves retention across different subject areas. Despite these positive findings, there remains limited empirical evidence on how CTCA is implemented in teaching and learning trigonometry in Nigerian secondary schools. Given the continuing poor performance and weak retention commonly associated with trigonometry, it is therefore necessary to examine the effect of the Culturo-Techno-Contextual Approach on students' performance and retention in trigonometry among senior secondary school students in Rivers East Senatorial District, Nigeria.

Gender-related concerns in mathematics education have continued to draw scholarly attention, particularly because of worries about differences in students' achievement and retention in mathematics-related subjects. While some studies suggest that male students often achieve higher performance in mathematics due to societal expectations, classroom participation patterns, and confidence in problem-solving tasks, other research shows that such differences are largely shaped by instructional approaches rather than by gender itself (Ebisine, 2017; Omeodu, 2019). Learner-centered, activity-based instructional strategies have been shown to give both male and female students comparable learning opportunities by fostering active participation, collaboration, and meaningful comprehension of concepts (Akinoso, 2016). In this context, the Culturo-Techno-Contextual Approach (CTCA), which emphasizes cultural relevance, contextualized learning, and technological integration, may cultivate an inclusive learning environment that enhances students' retention of trigonometry concepts regardless of gender. This makes it necessary to assess whether male and female students differ in their retention of trigonometry concepts when taught using CTCA.

Statement of the Problem

Despite the importance of trigonometry in secondary school mathematics and its wide application in science and technology-related fields, students' performance and retention in the subject remain persistently poor in Nigerian secondary schools. Reports from the West African Examinations Council Chief Examiners consistently reveal students' weaknesses in trigonometric concepts such as trigonometric identities, angles of elevation and depression, and the application of sine and cosine rules (WAEC, 2021–2023). These persistent difficulties have largely been attributed to conventional instructional approaches that emphasize rote memorization, procedural learning, and passive classroom participation without meaningful connection to students' cultural experiences and real-life contexts (Tyata et al., 2021; Folake & Ibidiran, 2021). Consequently, many students develop shallow conceptual understanding, resulting not only in poor academic performance but also weak retention of learned concepts over time. Although innovative learner-centered instructional approaches have been introduced to improve mathematics learning outcomes, many of these

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

approaches still fail to adequately integrate learners' cultural realities, technological exposure, and contextual experiences into classroom instruction. The Culturo-Techno-Contextual Approach (CTCA) was developed to address these gaps by combining cultural relevance, technological support, and contextual learning experiences to promote meaningful understanding and long-term retention of knowledge (Okebukola, 2020). Empirical studies have reported positive effects of CTCA on students' achievement and engagement in science-related subjects (Akintoye et al., 2024; Adam et al., 2024). However, there is limited empirical evidence on its effectiveness in improving students' performance and retention in trigonometry, particularly among senior secondary school students in Rivers East Senatorial District, Nigeria. This gap in knowledge necessitated the present study, which investigated the effect of the Culturo-Techno-Contextual Approach on students' performance and retention in trigonometry.

Purpose of the Study

The primary purpose of this study was to determine the effect of the Culturo-Techno-Contextual Approach (CTCA) on students' performance and retention in trigonometry among senior secondary school students in Rivers East Senatorial District. Specifically, the study seeks to:

1. Determine the difference in performance of students taught trigonometry using the Culturo-Techno-Contextual Approach (CTCA) and those taught using the Cooperative Learning method in Rivers East.

2. Examine the difference in the retention of students taught trigonometry using the Culturo-Techno-Contextual Approach (CTCA) and those taught using the Cooperative Learning method in Rivers East.

3. Determine the difference in the mean performance score of male and female students in trigonometry taught using the Culturo-Techno-Contextual Approach (CTCA) in Rivers East.

Research Questions

To achieve these objectives, the study answered the following research questions:

1. What is the difference in the mean performance scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and the Cooperative Learning method?

2. What is the difference in the mean retention scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and those taught using the Cooperative Learning method?

3. What is the difference in the mean performance scores of male and female students taught trigonometry using the Culturo-Techno-Contextual Approach?

Hypotheses

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

1. There is no significant difference in the mean academic performance scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and those taught using Cooperative Learning Method.

2. There is no significant difference in the mean retention scores of students taught Trigonometry using the Culturo-Techno-Contextual Approach and those taught using the Cooperative Learning Method.

3. There is no significant difference in the mean academic performance scores of male and female students taught Trigonometry using the Culturo-Techno-Contextual Approach.

METHODOLOGY

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

This study adopted a quasi-experimental research design involving pretest, posttest, and post-posttest measures with non-equivalent control groups. The design was considered appropriate because the study was conducted in a natural school setting where random assignment of individual students was not feasible, thereby necessitating the use of intact classes. The study was conducted in Rivers East Senatorial District of Rivers State, Nigeria. The district comprises eight Local Government Areas, namely Emohua, Etche, Ikwerre, Obio/Akpor, Okrika, Omuma, Ogu/Bolo, and Port Harcourt City. The population of the study comprised all students offering mathematics in public senior secondary schools within Rivers East Senatorial District. According to records obtained from the Planning, Research and Statistics Department of the Rivers State Senior Secondary Schools Board for the 2024/2025 academic session, the population consisted of 38,971 students across 153 public senior secondary schools.

A multistage sampling technique was employed to select the sample for the study. At the first stage, Rivers East Senatorial District was divided into four clusters based on geographical location and socio-cultural similarities. Two clusters were selected through simple random sampling using the balloting method, after which one Local Government Area was selected from each cluster using simple random sampling. At the second stage, two public secondary schools were purposively selected from each selected Local Government Area based on the availability of at least two intact SS2 classes and qualified mathematics teachers willing to participate in the study. At the final stage, two intact SS2 classes were randomly selected from each of the four schools, resulting in a total of eight intact classes. The sample for the study consisted of 334 Senior Secondary School Two (SS2) students, comprising 166 male and 168 female students. Four intact classes were assigned to the experimental group and taught using the Culturo-Techno-Contextual Approach, while the remaining four classes served as the control group and were taught using the Cooperative Learning Method.

The instruments used for data collection were the Basic Trigonometry Test (BTT), Trigonometry Performance Test (TPT), and Trigonometry Retention Test (TRT). The Basic Trigonometry Test served as the pretest instrument and was designed to assess students' prior knowledge and establish baseline equivalence between the groups before treatment. The Trigonometry Performance Test was used as the posttest instrument to measure students' academic performance in trigonometry after exposure to the instructional treatments. The test consisted of twenty multiple-choice items covering trigonometric ratios, sine rule, cosine rule, and angles of elevation and depression. The Trigonometry Retention Test was a reshuffled parallel version of the TPT administered two weeks after the posttest to assess students' retention of learned concepts. The instruments were subjected to face and content validation by experts in Mathematics Education and Measurement and Evaluation to ensure adequacy of content coverage, clarity of items, and suitability for SS2 students. The reliability indices obtained using the test–retest method yielded coefficients of 0.98 for the BTT and 0.93 for the TPT using Pearson Product Moment Correlation Coefficient.

The administration of the study was carried out in four phases, namely pretest, treatment, posttest, and post-posttest phases. Before the commencement of the treatment, the Basic Trigonometry Test was administered to both the experimental and control groups to determine students' entry behavior and establish baseline equivalence. The treatment lasted for four weeks during normal school instructional periods. The experimental group was taught using the Culturo-Techno-Contextual Approach following the five-step implementation framework proposed by Peter A. Okebukola. The control group, on the other hand, was taught the same trigonometry topics using the Cooperative Learning Method. At the end of the treatment, the Trigonometry Performance Test was administered as the posttest, while the Trigonometry Retention Test was administered two weeks later without prior notice to assess students' retention of learned concepts.

Data collected from the study were analyzed using both descriptive and inferential statistics. The mean and standard deviation were used to answer the research questions, while One-Way Analysis of Covariance (ANCOVA) and an independent-samples t-test were used to answer the research hypothesis. The use of ANCOVA enabled the researcher to adjust for possible initial group differences and provided a more accurate estimate of the treatment effect. Ethical considerations were also observed through obtaining permission from relevant school authorities, ensuring informed consent, maintaining confidentiality of participants' responses, and guaranteeing voluntary participation throughout the study.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

RESULT

Research Question 1: What is the difference in the mean performance scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and the Cooperative Learning method?

Table 1: Mean and standard deviation of Students Academic Performance taught Trigonometry using Culturo-Techno-Contextual Approach and Cooperative Learning method

Method	**N**	**Pre-Test (BTT)**		**Post Test (TPT)**	
		Mean	**SD**	**Mean**	**SD**
CTCA	164	45.34	10.897	73.93	8.753
Cooperative Learning Method	170	44.15	9.577	64.24	8.686
Mean Difference (Between)	—	**1.19**		**9.69**	

In Table 1, the results indicate that students in the CTCA group had a slightly higher mean score (M = 45.34, SD = 10.897) than those in the Cooperative Learning group (M = 44.15, SD = 9.577) at the pre-test level, with a mean difference of 1.19, suggesting that both groups were relatively comparable before treatment. However, at the post-test level, students taught using CTCA recorded a higher mean score (M = 73.93, SD = 8.753) compared to their counterparts taught using the Cooperative Learning method (M = 64.24, SD = 8.686), with a mean difference of 9.69. This indicates an Observable improvement in performance in favour of the CTCA group after the treatment.

Research Question 2: What is the difference in the mean retention scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and those taught using the Cooperative Learning method?

Table 2: Mean and standard deviation of Post-Test and Retention Scores of Students taught Trigonometry using Culturo-Techno-Contextual Approach and Cooperative Learning method

Method	**N**	**Post-Test (TPT)**		**Retention Test**	
		Mean	**SD**	**Mean**	**SD**
CTCA	164	73.93	8.753	68.90	10.509
Cooperative Learning Method	170	64.24	8.686	60.09	11.047
Mean Difference (Between)	—	9.69	—	8.81	—

The results in Table 2, shows that students in the CTCA group had a mean score of 73.93 (SD = 8.753) in the post-test and a retention mean score of 68.90 (SD = 10.509). On the other hand, students taught using the Cooperative Learning Method had a post-test mean score of 64.24 (SD = 8.686) and a retention mean score of 60.09 (SD = 11.047). The difference in retention mean scores between the two groups is 8.81, in favour of the CTCA group. Similarly, the difference in post-test mean scores is 9.69, also favouring the CTCA group.

Research Question 3: What is the difference in the mean performance scores of male and female students taught trigonometry using the Culturo-Techno-Contextual Approach?

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

Table 3: Mean Performance Scores of Male and Female Students taught trigonometry using the Culturo-Techno-Contextual Approach

Method	**N**	**Pre-Test (BTT)**		**Post-Test (TPT)**		
		Mean	**SD**	**Mean**	**SD**	
Male	81	45.18	11.692	73.35	8.786	
Female	83	45.49	10.11	74.51	8.735	
Differences Between	—	0.31	—	1.15	—	0.65

The result shows that male students had a mean pre-test score of 45.18 with a standard deviation of 11.692, while female students had a slightly higher mean pre-test score of 45.49 with a standard deviation of 10.11. The mean difference (Between) of 0.31 indicates that both groups had nearly identical baseline performance levels prior to the treatment. At the post-test level, male students recorded a mean score of 73.35 with a standard deviation of 8.786, whereas female students had a mean score of 74.51 with a standard deviation of 8.735. The mean difference (Between) of 1.15 suggests a slight advantage in favour of female students after exposure to the instructional approach. However, whether the observed difference in performance between male and female students is statistically significant was determined using inferential statistics, as presented in the hypothesis testing.

Hypothesis 1: There is no significant difference in the mean academic performance scores of students taught trigonometry using the Culturo-Techno-Contextual Approach and those taught using Cooperative Learning Method.

Table 4: ANCOVA Analysis on the Academic Performance of Students taught Trigonometry using Culturo-Techno-Contextual Approach and those taught using Cooperative Learning Method.

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	20,710.589	2	10,355.295	276.902	.000	.626
Intercept	29,067.195	1	29,067.195	777.260	.000	.701
Pre_BTT	12,860.443	1	12,860.443	343.890	.000	.510
Method	6,702.417	1	6,702.417	179.223	.000	.351
Error	12,378.408	331	37.397	—	—	—
Total	1,623,125.000	334	—	—	—	—
Corrected Total	33,088.997	333	—	—	—	—

The results presented in Table 4 indicate that there was a statistically significant effect of instructional method on students' post-test trigonometry performance scores after controlling for pre-test differences. This is evident by $F(1, 331) = 179.223$, $p < .05$, with a partial eta squared (η^2_p) of .351. Based on this result, the hypothesis was rejected. This indicates that there was a significant difference in the academic performance of students taught using the Culturo-Techno-Contextual Approach and those taught using the Cooperative Learning Method after controlling for pretest scores, in favour of the Culturo-Techno-Contextual Approach (CTCA) group.

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume XI Issue VIII August 2026

Hypothesis 2: There is no significant difference in the mean retention scores of students taught Trigonometry using the Culturo-Techno-Contextual Approach and those taught using the Cooperative Learning Method.

Table 5: Independent Samples t-test of Difference in Mean Retention Scores between CTCA and Cooperative Learning Groups

Variable	Group Comparison	N	Mean Difference	Std. Error Difference	t	df	Sig. (2-tailed)	95% CI (Lower, Upper)
Retention Test	CTCA vs Cooperative Learning Method	334	8.814	1.181	7.466	332	.000	(6.492, 11.137)

Table 5 shows the independent samples t-test analysis of the difference in retention scores between students taught using the Culturo-Techno-Contextual Approach (CTCA) and those taught using the Cooperative Learning Method. Levene's test for equality of variances was not significant ($F = 0.241$, $p = 0.624$), indicating that the assumption of homogeneity of variance was met. Therefore, the statistics for equal variances assumed were adopted. The result revealed that there was a statistically significant difference in the mean retention scores of the two groups ($t(332) = 7.466$, $p < 0.05$). Since the p-value is less than 0.05, the null hypothesis is rejected. This implies that there is a significant difference in the retention scores of students taught using CTCA and those taught using the Cooperative Learning Method. The mean difference of 8.814 indicates that one instructional method led to higher retention of trigonometry concepts than the other. CTCA enhances retention better

Hypothesis 3: There is no significant difference in the mean academic performance scores of male and female students taught Trigonometry using the Culturo-Techno-Contextual Approach.

Table 6: Independent Samples t-test of Difference in Academic Performance of Male and Female Students Taught Trigonometry Using the Culturo-Techno-Contextual Approach (CTCA)

Gender	N	Mean	Std. Deviation	Std. Error Mean	Df	t-cal	p-value
Male	81	73.35	8.786	.970	162	-0.847	0.398
Female	83	74.51	8.735	.965			

In Table 6, the independent-samples t-test result reveals that there is no statistically significant difference in the mean scores of male and female students taught using the Culturo-Techno-Contextual Approach, $t(162) = -0.847$, $p = 0.398$. Since the p-value (0.398) is greater than the 0.05 level of significance, the null hypothesis is not rejected. This implies that male and female students performed similarly when taught using the Culturo-Techno-Contextual Approach. In other words, the effectiveness of the approach is not influenced by gender.

DISCUSSION

The findings of this study revealed that students taught trigonometry using the Culturo-Techno-Contextual Approach (CTCA) performed significantly better than those taught using the Cooperative Learning Method. The result showed that students exposed to CTCA recorded higher post-test mean scores than their counterparts in the Cooperative Learning group, and the ANCOVA analysis further established that the observed difference was statistically significant. This finding implies that CTCA is more effective in improving students' academic performance in trigonometry. The improved performance may be attributed to the learner-centered nature of CTCA, which integrates students' cultural experiences, technological tools, and contextual real-life applications into classroom instruction. These features likely reduced the abstractness of

trigonometry and enhanced students' conceptual understanding. The finding is consistent with the submission of Okebukola (2020), who explained that CTCA promotes meaningful learning by connecting classroom concepts with learners' lived experiences. The finding also agrees with Akintoye et al. (2024), who reported that students taught using CTCA achieved significantly higher academic performance and engagement than those taught using conventional instructional methods. Similarly, Adam et al. (2024) found that CTCA enhanced students' conceptual understanding and academic achievement through active participation and contextualized instruction.

The finding further supports the constructivist theory of learning proposed by Jerome Bruner, which emphasizes that learners understand concepts better when they actively participate in the learning process and construct knowledge from meaningful experiences (Bruner, 1961). Through culturally familiar examples, collaborative activities, and technological visualization, students in the CTCA group were able to relate trigonometric concepts to real-life situations, thereby improving comprehension and problem-solving abilities. This finding also corroborates the earlier position of Oladejo et al. (2025), who concluded from a systematic review that CTCA consistently improves students' learning outcomes across STEM disciplines by promoting engagement, contextual understanding, and active learning.

The study also revealed that students taught trigonometry using CTCA retained learned concepts better than those taught using the Cooperative Learning Method. The result indicated that the CTCA group had significantly higher retention scores than the Cooperative Learning group, and the independent samples t-test confirmed that the difference was statistically significant. This finding suggests that CTCA enhances long-term retention of trigonometric concepts more effectively than the Cooperative Learning Method. The likely explanation for this outcome is that CTCA promotes meaningful learning through practical engagement, contextual applications, and technological reinforcement, which strengthen students' cognitive understanding and memory retention. The finding agrees with the view of David Ausubel that meaningful learning occurs when new information is linked to learners' prior knowledge and existing cognitive structures (Ausubel, 1962). The finding is also in line with Wilcox et al. (2020), who reported that students retain concepts more effectively when they are actively engaged in meaningful and interactive learning experiences rather than passive memorization. Similarly, Oladejo et al. (2022) noted that students demonstrate better retention when instruction is connected to familiar experiences and real-life applications. The technological and contextual dimensions of CTCA may have strengthened students' visualization and understanding of trigonometric relationships, thereby reducing forgetting and enhancing retention over time. The finding further supports Adam et al. (2024), who found that CTCA significantly improved students' retention and conceptual understanding in science subjects through contextualized and technology-supported instruction.

Furthermore, the study revealed that there was no statistically significant difference in the academic performance scores of male and female students taught trigonometry using CTCA. Although slight mean differences were observed between male and female students, the independent samples t-test showed that the difference was not statistically significant. This finding indicates that CTCA is gender-friendly and equally effective for both male and female students in improving academic performance in trigonometry. The finding suggests that the learner-centered and inclusive nature of CTCA provides equal learning opportunities regardless of gender. This result is consistent with the findings of Omeodu (2020), who reported that achievement differences in mathematics are more dependent on instructional conditions than gender differences. Similarly, the finding corroborates the study of Akintoye et al. (2024), which found that instructional approaches that promote active participation, contextual learning, and meaningful engagement enhance learning outcomes equally among male and female students. The finding therefore implies that CTCA can effectively bridge gender disparities in mathematics learning by creating an inclusive and supportive learning environment for all students.

CONCLUSION

Based on the findings of this study, it was concluded that the Culturo-Techno-Contextual Approach (CTCA) is an effective instructional approach for improving students' performance and retention in trigonometry among senior secondary school students in Rivers East Senatorial District, Nigeria. Students exposed to CTCA

demonstrated higher academic achievement and retained trigonometric concepts better than their counterparts taught using the Cooperative Learning Method. The effectiveness of CTCA may be attributed to its integration of cultural experiences, contextualized learning activities, and technological tools, which made abstract trigonometric concepts more meaningful, practical, and easier to understand. The approach also promoted active participation, collaborative learning, and deeper conceptual understanding, thereby enhancing long-term retention of learned concepts. The study therefore established that incorporating culturally relevant and technology-supported instructional practices into mathematics teaching can significantly improve students' learning outcomes in trigonometry.

RECOMMENDATIONS

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

1. Mathematics teachers should adopt the Culturo-Techno-Contextual Approach (CTCA) in the teaching of trigonometry and other abstract mathematics concepts in order to improve students' academic performance and retention.

2. Curriculum developers and educational authorities should integrate culturally relevant and technology-supported instructional strategies such as CTCA into the secondary school mathematics curriculum and teacher training programmes.

3. School administrators and government agencies should provide adequate technological facilities, including multimedia resources and internet-enabled instructional tools, to support the effective implementation of CTCA in mathematics classrooms.

4. Workshops, seminars, and professional development programmes should be organized regularly for mathematics teachers to enhance their competence in the application of the Culturo-Techno-Contextual Approach and other innovative learner-centered instructional strategies.

REFERENCES

1. Adam, U. A., Lameed, S. N., Owolabi, T., Onowugbeda, F. U., Oladejo, A. I., Okebukola, P. A., & Mustapha, G. A. (2024). The potency of culture, technology, and context in a biology classroom: Culturo-Techno-Contextual Approach in action. International Journal of Science Education, 1–26.
2. Akinoso, A. O. (2016). Effects of cooperative and competitive learning strategies on senior secondary school students' learning outcomes in mathematics. Journal of Mathematics Education, 9(1), 45–53.
3. Akintoye, H. O., Elemoro, S. A., & Ogunyemi, T. G. (2024). Impacts of the Culturo-Techno-Contextual Approach on critical thinking of secondary school students in learning difficult concepts in physics. FNAS Journal of Mathematics and Science Education, 6(1), 138–145.
4. Akintoye, H. O., Oladejo, A. I., Onowugbeda, F. U., Oludipe, O. S., Abdulkareem, K. M., Bankole, I., & Adam, U. A. (2024). Investigating the impact of the Culturo-Techno-Contextual Approach on enhancing critical thinking in science: Gender dynamics and learning efficacy. Journal of Educational Sciences, 656–670.
5. Ausubel, D. P. (1962). A subsumption theory of meaningful verbal learning and retention. The Journal of General Psychology, 66(2), 213–224. https://doi.org/10.1080/00221309.1962.9711837
6. Baddeley, A. (2020). Working memory. In Memory (pp. 71–111). Routledge.
7. Bekene Bedada, T., & Machaba, F. (2022). The effect of GeoGebra on STEM students' learning of trigonometric functions. Cogent Education, 9(1), 2034240.
8. Dhungana, S., Pant, B. P., & Dahal, N. (2023). Students' experience in learning trigonometry in high school mathematics: A phenomenological study. Mathematics Teaching Research Journal, 15(4), 184–201.
9. Ebisine, E. B. (2017). Effect of problem-solving instructional strategy on the academic performance of Nigerian students in mathematics based on gender. Educational Research Review, 3(1), 23.

10. Folake, A. C., & Ibidiran, R. J. (2021). A technique for exploring students' views of the world through mathematical thinking. Physics Education, 15(6), 376–379. https://doi.org/10.1088/0031-9120/15/6/312
11. Gómez-Chacón, I. M., Bacelo, A., Marbán, J. M., & Palacios, A. (2023). Inquiry-based mathematics education and attitudes towards mathematics: Tracking profiles for teaching. Mathematics Education Research Journal. https://doi.org/10.1007/s13394-023-00468-8
12. Odor, E. E., Owan, V. J., & Agama, V. U. (2023). Trigtastrophe: Analysis of the process errors senior secondary students commit in solving trigonometric problems. Journal of Educational Research in Developing Areas, 4(2), 123–138. https://doi.org/10.47434/JEREDA.4.2.2023.138
13. Okebukola, P. A. (2020). Breaking barriers to learning: The culture-techno-contextual approach (CTCA). Sterling Publishers.
14. Oladejo, A., Akinola, V., Ebisin, A., & Olateju, T. T. (2022). Culturally relevant pedagogies in enhancing students learning of ICT concepts: A test of the efficacy of CTCA. West African Journal of Open & Flexible Learning, 11(1).
15. Oladejo, A. I., Olateju, T. T., Okebukola, P. A., Sanni, R., Akintoye, H., Onowugbeda, F., Ayanwale, M. A., Agbanimu, D. O., Saibu, S., & Adam, U. (2025). Breaking barriers to meaningful learning in STEM subjects in Africa: A systematic review of the culturo-techno-contextual approach. Sustainability, 17, 2310. https://doi.org/10.3390/su17052310
16. Omeodu, M. D. (2020). Gender parity in mathematics and entrepreneurship education for national development. International Journal of Education, Learning and Development, 7(12), 1–10.
17. Tyata, R. K., Dahal, N., Pant, B. P., & Luitel, B. C. (2021). Exploring project-based teaching for engaging students' mathematical learning. Mathematics Education Forum Chitwan, 6(6), 30–49. https://doi.org/10.3126/mefc.v6i6.42398
18. WAEC. (2021). Chief examiner's report of West African Examination Council on the performance of candidates in Mathematics Paper 2.
19. WAEC. (2022). Chief examiner's report of West African Examination Council on the performance of candidates in Mathematics Paper 2.
20. WAEC. (2023). Chief examiner's report of West African Examination Council on the performance of candidates in Mathematics Paper 2.
21. Wilcox, B. R., Pollock, S. J., & Bolton, D. R. (2020). Retention of conceptual learning after an interactive introductory mechanics course. Physical Review Physics Education Research, 16(1), 010140.