

DOI: 10.5281/zenodo.20766565

CULTURO-TECHNO-CONTEXTUAL APPROACH: AN INDIGENOUS PARADIGM FOR REDUCING MATHEMATICS ANXIETY AND ENHANCING ACADEMIC PERFORMANCE

Ola Tokunbo Odekeye¹ and Thuthukile Jita²

^{1,2}Department of Curriculum Studies and Higher Education, University of the Free State. South Africa.

Received: 05/04/2026
Accepted: 05/05/2026

Corresponding Author: Ola Tokunbo Odekeye
(odekeyeot.@ufs.ac.za)

ABSTRACT

This study investigated the potency of the culturo-techno-contextual approach (CTCA) as a paradigm for reducing student anxiety and improving academic performance in trigonometry, a topic widely regarded as challenging in mathematics. Using a quasi-experimental pretest-posttest non-equivalent groups design, data were collected from 119 Senior Secondary School II (SS2) mathematics students in Lagos State, Nigeria. Findings revealed that the experimental group taught with CTCA had a lower level of anxiety ($M=11.28$, $SD = 2.36$ and performed significantly better ($M = 20.72$, $SD = 3.26$) in trigonometry than the control group, with a higher level of anxiety ($M=16.31$, $SD = 2.79$) and lower academic performance ($M = 13.71$, $SD = 3.81$). taught with the conventional method. These results validated the efficacy of adopting a cultural and contextual knowledge strategy for teaching mathematics. It is therefore recommended that teachers should integrate CTCA frameworks to improve students' understanding of trigonometry.

KEYWORDS: CTCA, Indigenous Paradigm, Mathematics Anxiety, Academic Performance.

1. INTRODUCTION

Anxiety remains a pervasive barrier to effective learning across educational contexts, particularly in mathematics education. It is typically characterised by feelings of tension, apprehension, and fear that can significantly impair cognitive processing and academic performance (Ashcraft, 2002; Egara & Mosimege, 2025). Empirical evidence indicates that elevated anxiety levels undermine learners' confidence, concentration, and overall achievement (Cruz et al., 2026; McCurdy et al., 2023). Within mathematics, this phenomenon manifests as mathematics anxiety, defined as the fear or tension that interferes with the manipulation of numbers and problem-solving. Studies have consistently identified mathematics anxiety as a critical factor contributing to poor learning outcomes (Barroso et al., 2021; Oladejo et al., 2023).

A growing body of research attributes this challenge, in part, to the pedagogical approaches commonly employed in mathematics classrooms. Teacher-centred instructional methods, limited contextualisation of content, and inadequate pedagogical content knowledge have been identified as key contributors to students' negative learning experiences (Odumosu et al., 2018; Samuel & Warner, 2021). Despite numerous instructional innovations, including cooperative learning, concept mapping, project-based learning, and constructivist approaches, students' performance in mathematics and related STEM subjects remains persistently low in many contexts (Awofala & Lawani, 2020; Kokotsaki et al., 2016; Torre et al., 2023). This persistent trend suggests the need for more contextually responsive and integrative pedagogical frameworks.

Recent attention has therefore shifted towards culturally responsive teaching, which emphasises integrating learners' cultural backgrounds and lived experiences into instructional practices. This approach has been shown to enhance student engagement, motivation, and achievement, particularly within African educational contexts (Ademola et al., 2023; Gbeleyi et al., 2022; Odekeye et al., 2025). Scholars such as Gay (2018) and Ladson-Billings (2014) argue that meaningful learning occurs when students see their identities and experiences reflected in the curriculum. While culturally responsive teaching addresses the cultural dimension of learning, there remains a need to incorporate technological and contextual elements in a more structured, holistic manner.

In response to this gap, the Culturo Techno Contextual Approach has emerged as an innovative

pedagogical framework that integrates cultural relevance, technological tools, and contextualised learning experiences. By situating mathematical concepts within students' sociocultural realities and leveraging digital resources, this approach can enhance conceptual understanding while reducing affective barriers, such as anxiety.

Against this backdrop, the present study investigates the effectiveness of the Culturo Techno Contextual Approach in reducing students' mathematics anxiety and improving academic performance in trigonometry. Specifically, the study addresses the research question: Does the use of the Culturo Techno Contextual Approach reduce mathematics anxiety and enhance students' academic performance? The null hypothesis tested was that there is no statistically significant main effect of the treatment on students' anxiety levels and academic performance in trigonometry.

2. LITERATURE REVIEW

2.1 The CTCA Operational Framework

Peter Okebukola conceptualised the Culturo-Techno-Contextual Approach (CTCA). It is a comprehensive pedagogical framework designed to promote students' engagement and inclusiveness during the teaching process (Okebukola, 2020). CTCA was designed to address anxiety in science and science-related subjects by removing barriers to learning through the use of indigenous languages and contextual examples. The proponent of the CTCA argues that the primary goal of every teacher is to ensure that students understand the concepts taught in a meaningful manner. The approach is anchored in three interrelated concepts: (a) cultural alignment, which relies heavily on indigenous knowledge, (b) technological application, the intervention that makes teaching and learning effective and (c) contextual grounding, which includes the significant examples or case studies used to explain the content (See Figure 1).



Figure 1: The framework of CTCA

These elements are systematically embedded within a particular instructional framework to promote students' active participation, improve academic performance and advance equity in learning outcomes. CTCA strongly emphasises inclusiveness by acknowledging learners' cultural background, languages, diverse identities and lived experiences. In the CTCA framework, culture is a component that integrates indigenous knowledge, language, and belief. Teachers are expected to create meaningful experiences that draw on learners' sociocultural backgrounds to provide clearer explanations of the concepts. The aim is to establish a strong connection between the teacher's instruction and learners' cultural backgrounds to make the learning experience meaningful and relevant.

Technological and media integration now plays a significant role in Africa. It is used to promote communication, collaboration, creativity, demonstration and to search for knowledge about the natural world. In today's world, AI tools and social media have significantly improved students' learning outcomes. Learners now have a better understanding because they can independently search for knowledge online using different search engines, such as Google Chrome and Mozilla, or even watch YouTube. According to Hemal et al. (2024), technology-enabled platforms encourage learners' cognitive and behavioural engagement. So, one of the bases of CTCA is the integration of the technology used to improve the teaching and learning of difficult topics.

The third component of the approach is the context, which refers to the learning environment in which the teacher provides instructions to learners. The contextual aspect of the CTCA framework is drawn from the learner's immediate and physical environment. Examples used should be localised to reflect students' everyday experiences. Incorporating local examples into the teaching and learning process allows students to draw relevant connections between the taught content and practical scenarios in their immediate environment.

2.2. Step-by-Step Procedure for Implementing CTCA in the Classroom

The Culturo-Techno-Contextual Approach is implemented through a five-step, well-structured process that blends culture, technology, and learners' contextual environments. This followed the five-step process outlined in the model suggested in Figure 2 to reduce students' anxiety and improve their academic performance in mathematics.

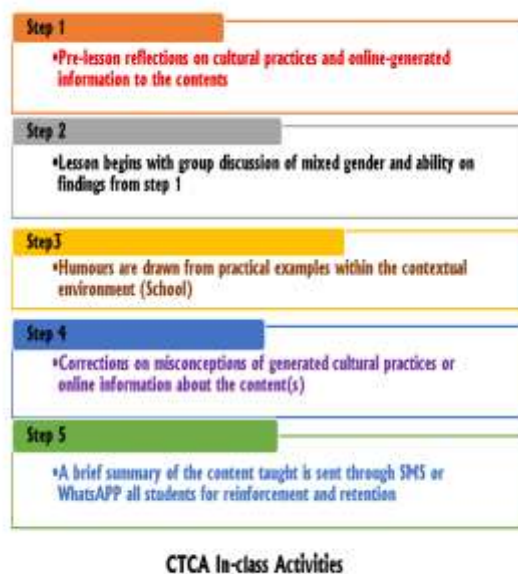


Figure 2: CTCA implementation

The first steps begin before the start of the actual class, when learners are introduced to the content and encouraged to reflect on cultural knowledge related to it from home. This includes indigenous practices, community experience and everyday belief related to the content. Learners are also allowed to use technology-enabled devices or platforms to search for relevant information to help them prepare well for the class.

The second step begins at the start of the class, when learners are grouped by gender and ability to share their cultural reflections and information generated in their group. Someone from each group will present their ideas to the entire class. The teacher responds after each group presentation, offering meaningful cultural examples.

The third step allows the teacher to make teaching and learning more practical by giving familiar examples or illustrations from the school environment to explain the lesson content. This allows the learners to connect with the content and real-life experiences for better understanding.

The fourth step is designed for correcting any misconceptions. This allows the learners to revisit their earlier reflections while the teacher patiently clarifies any misunderstandings or areas of confusion. This stage ensures that learning of the content is accurate, meaningful, and well understood.

In the fifth and final step, the teacher provides a short, clear summary of the class content via SMS or WhatsApp. The implication of this approach is that

learning becomes completely learner-centred, where peer-led team learning is encouraged.

2.3 The Need for Cultural Responsiveness in Teaching Mathematics

The need for cultural responsiveness in mathematics teaching stems from the recognition that learners construct new knowledge based on their existing experiences, values, and cultural understandings (Supriyanto et al., 2026). Teaching mathematics through culture acknowledges and utilises students' prior knowledge, enabling them to connect abstract mathematical concepts with familiar real-life experiences, thereby fostering deeper understanding and meaningful learning (Suherman et al., 2021). Culturally responsive teaching involves the deliberate integration of cultural considerations into curriculum content, learning environments, classroom interactions, instructional strategies, classroom management practices, and assessment processes (Ladson-Billings, 1999). Within mathematics education, this approach seeks to bridge the disconnect between formal mathematical knowledge and learners' cultural realities by incorporating students' cultural identities, traditions, and community-based knowledge into instructional practices (Abdulrahim & Orosco, 2019).

Research has consistently demonstrated that students exposed to culturally grounded learning experiences engage more actively and meaningfully with mathematical concepts, resulting in improved understanding and participation (Luzano, 2025; Rigney et al., 2023). Furthermore, the Cultural Teaching and Community Approach (CTCA) has emerged as an effective instructional strategy for enhancing students' academic achievement in mathematics, as it promotes active learner participation, facilitates conceptual understanding, and helps address common misconceptions that often hinder learning (Odekeye et al., 2025; Okebukola, 2020; Oladejo et al., 2023). Consequently, culturally responsive mathematics instruction offers a pathway for making mathematics more relevant, accessible, and meaningful to diverse learners while improving educational outcomes.

2.4 Theoretical Framework

The Culturo-Techno-Contextual Approach (CTCA) is a framework in its own right, grounded in the principles of social constructivism and culturally relevant pedagogy. It is primarily drawn from Vygotsky's theory of social constructivism and Ladson-Billings' theory of culturally relevant pedagogy. According to Vygotsky (1978), learning

occurs through social interaction, which is shaped by cultural context, language and engagement within the learners' Zone of Proximal Development (ZPD). In line with this perspective, CTCA is designed to align with activities that will promote guided learning, social interaction, discussion and collaboration with more experienced people. It underscores the roles of social interaction and relevant behaviour in shaping one's knowledge relevant to the environment. Similarly, Ladson-Billings (1995) argues that effective teaching should sustain learners' cultural identities, promote academic success and foster critical awareness. CTCA integrates all these principles by connecting the students' cultural experiences with scientific learning through appropriate technological tools.

3. METHODOLOGY

3.1 Research design

A quantitative data gathering method was employed in this study. The research design was a quasi-experimental design with pre-test and post-test measures and non-equivalent random assignment of students to the experimental and control groups during data collection (Reichardt, 2009). Only the experimental group in this study received an intervention before the posttest was administered to both groups. Quasi-experimental designs are commonly used in educational research because they provide strong internal validity through the use of experimental and control groups, while also supporting external validity by evaluating the intervention in real-world settings where random assignment is often not possible. The implication is that the results of such a study can be applied to similar educational settings while simultaneously addressing factors that could influence the accuracy or reliability of the results (Gopalan & Tyagi, 2020).

3.2 Sample and instrumentation

A total of 119 Senior Secondary School II (SS2) students participated in this study from two purposively selected government-owned schools in Lagos Education District V in Nigeria. The schools were selected due to convenience and proximity. SS2 students in Nigeria are equivalent to Year 12 students in the United Kingdom or Grade 11 students in the United States. The students' intact classes were assigned to the control ($n = 52$; male = 25; female = 27) and the experimental ($n = 43$; male = 20; female = 23) groups nonrandomly (Reichardt, 2009). The participants' average age was 16 years. SS2 students were selected for the study because the Lagos State Curriculum shows that they have not yet learned the

main concept of trigonometry. Yet, they should have learned it at their Junior Secondary School and have a background understanding of it.

The Trigonometry Anxiety Scale was adapted from the Mathematics Anxiety Rating Scale and related mathematics anxiety instruments, such as the Abbreviated Mathematics Anxiety Scales developed by Hopko et al. (2003). For this study, the items were modified to reflect students' cognitive, affective and physiological reactions specifically to trigonometry learning situations. The instrument was validated with the assistance of an instrument validation expert, comprising mathematics teachers and a test construction specialist, to ensure it measures what is expected to measure. The instrument was used to evaluate students' mathematics anxiety and to evaluate if the intervention used was able to reduce any math-related anxiety and improve academic performance by building their confidence. The instrument was structured on a five-point Likert scale, with 10 positive and 10 negative words, to measure students' level of trigonometry anxiety. The instrument was validated using SS2 students who were not part of the study group. This was done twice, with a two-week interval, to the same set of students. The data were then analysed using IBM SPSS version 23, and a reliability coefficient of 0.79 was obtained.

The second instrument is titled: Angle of Elevation and Depression Achievement Test (AEDAT). This instrument was developed to align with the Nigerian Secondary School Mathematics Curriculum to assess students' academic performance in trigonometry. The initial draft of the instrument contained 57 multiple-choice items, but through validation test construction with a specialist and contributions from three mathematics experts who are currently seasoned teachers at that level, the items were reduced to 40. These items were adapted from the National Examination Council and the West African Senior School Certificate Examination (WASSCE) mathematics past question papers. Each question carried equal marks, and students were

allowed to choose the correct answer from options A-D. Marks were awarded manually, with 1 point per correctly answered item. The instrument's reliability was assessed using the split-half method among students at the same level and with the same characteristics as the study sample. The coefficient of 0.77 was obtained for the instrument using the Pearson product-moment correlation in IBM SPSS version 23. The instrument included Section A to collect demographic information from the students and Section B to evaluate the behavioural objectives highlighted in the lesson for the research study.

3.3 Data collection

The study began by seeking permission from the appropriate authorities in the participating schools. After this, the Angle of Elevation and Depression Scale and the Angle of Elevation and Depression Achievement Test (pre-test) were administered to all the students in the control and experimental groups. The experimental group students were given an orientation about the treatment, the culturo-techno-contextual approach. The purpose was to give them a basic understanding of how the teaching strategy works. After providing them with the necessary orientation, the treatment lasted 6 weeks, during which students learned trigonometry using indigenous knowledge. These students were taught using the culturo-techno-contextual approach, while the control group received no treatment but used the traditional method.

3.3.1 Treatment implementation in the experimental group

The implementation was associated with cultural and contextual knowledge relevant to the teaching of angles of elevation and depression, using the five-step procedure outlined by the CTCA (<http://ctcapproach.com>). Indigenous knowledge was used first to explain some trigonometric terms in Yoruba to help students develop a background understanding of the content. (See Table 1)

Table 1: Showing indigenous trigonometric terminologies in Yoruba.

S/N	Trigonometry terms	Yoruba translations	Classroom understanding
1	Trigonometry	Ìṣirò ìgun mèta	Show a triangle with sides labelled and angles marked. Discuss ratios: sine, cosine, tangent
2	Angle	Igun	Draw an angle at the intersection of two lines. Label the vertex and arms.
3	Height / Altitude	Gìgùn / Iga	Label the vertical side of a triangle or a building as height.
4	Tangent	Tánjẹ̀nítì	Mark opposite and adjacent sides in a right triangle and note $\tan \theta = \frac{\text{opposite}}{\text{adjacent}}$.

5	Sine	Sáini	Mark opposite and hypotenuse sides in a right triangle, and note $\sin \theta = \text{opposite/hypotenuse}$.
6	Cosine	Kósáini	Mark the adjacent and hypotenuse sides in a right triangle and note $\cos \theta = \text{adjacent / hypotenuse}$.
7	Latitude	Ìpò àgbáyé / Ipele ilẹ̀	Draw a globe with lines representing latitude north and south of the equator.
8	Equator	Ààrin ilẹ̀ / Èkó àgbáyé	Draw the equator line on a globe, and label the Northern and Southern hemispheres.

The cultural knowledge used to explain the angle of elevation was derived from the students' immediate learning environment, common across many Nigerian communities, where school water tanks are mounted on a raised metal/ block stand. This refers to omi tánkì ilé-ìwé lórí irin. An average school in Nigeria usually have a water tank placed on a scaffolding structure to supply water to the school buildings. When a student stands on the school compound and looks up at the water tank, the line of sight forms an angle between the student's horizontal eye level and the tank. This situation represents the angle of elevation, which occurs when an observer looks upward from a lower position to an object above. The angle of depression was drawn from the indigenous hunting practice common in rural areas of Nigeria, particularly in the Western

region. This practice describes a hunter hiding in a tree watching to kill an animal below (òdẹ tó jókòó lórí igi ní wo ẹranko ní isalẹ). This illustrates a hunter observing an animal from the tree. The angle formed between the hunter's horizontal line and the downward direction toward the animal represents the angle of depression, helping learners understand that it occurs when an observer looks downward from a higher position to an object below. These culturally familiar examples provide meaningful contexts for explaining trigonometric concepts. By linking mathematical ideas, such as angles of elevation and depression, to everyday indigenous experiences, learners can relate these concepts to their local environment in meaningful, scientific ways. (See Figure 3).



Figure 3: Cultural knowledge associated with angle elevation and depression

The concept of the trigonometric ratio was further explained using the school environment. A student is asked to stand on the school field and look up at a tree, trying to estimate its height. The situation forms a right-angled triangle, which helps to explain trigonometric relationships. In this scenario, the student's line of sight to the top of the tree forms the

triangle's hypotenuse, the slanted side. The distance from the student to the base of the tree along the ground represents the adjacent side, while the tree's vertical height represents the opposite side of the triangle. Using these contextual examples, students can understand trigonometric ratios. (See Figure 4).

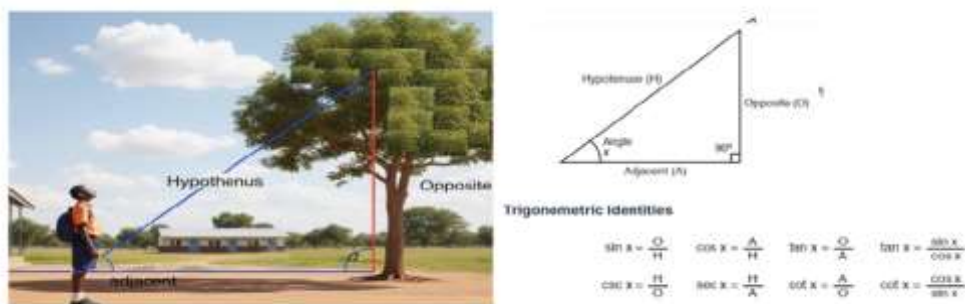


Figure 4: Cultural knowledge associated with trigonometric ratios

ratios

In this indigenous context, the height of the tree can be calculated using the tangent ratio if the distance from the student to the tree and the angle of elevation are known. This practical example helps learners understand how trigonometry can be used to measure the height of objects without climbing buildings, thereby enabling the practical, contextual application of trigonometric ratios in real-life situations.

3.2.2. Non-treatment Condition in the Control Group

The students in the control group were taught the same content with the same amount of time using the traditional methods. The content of angles of elevation and depression was handled by their teacher, including any elements of treatment or intervention that fall within the normal class teacher-student discussions. The traditional method involves the teacher introducing the topic and explaining terms and definitions with examples, not unlike the way it used to be. After both groups had their six weeks of teaching and learning. A posttest anxiety scale and a posttest achievement test were administered to them to measure the extent to which the two methods were effective.

4. RESULTS

Prior to conducting the Multivariate Analysis of Covariance (MANCOVA), a preliminary analysis was conducted to determine whether the assumptions required for MANCOVA were met. The assumption of normality was tested using the Shapiro-Wilk test. The results showed that post-test on the academic performance measure were normally distributed for the experimental group ($W = 0.96, p > .05$), but on the post-test anxiety measure, there was a violation of the assumption of normality ($W = .936, p < .05$). The assumption of equality of covariance matrices was also tested using Box's M

test. The results indicated that the covariance matrices of the dependent variables were equal across groups (Box's $M = 3.839, F = 1.249, p > .05$). Further to the preliminary tests, Levene's test of equality of error variances showed that the homogeneity of variance assumption was met on the measure of academic performance ($F = .246, p > .05$) but violated on the anxiety measure ($F = 4.872, p < .05$). However, despite these violations, MANCOVA was considered appropriate because of its robustness.

To examine the baseline of the two groups before the treatment, students' pre-test scores on mathematics anxiety and academic performance were analysed and the results showed that the experimental group ($M = 32.80, SD = 4.22$) and the control group ($M = 32.85, SD = 4.74$) had comparable levels of anxiety before the treatment. Similarly, the pre-test academic performance scores of the experimental group ($M = 5.98, SD = 2.33$) and the control group ($M = 5.81, SD = 2.39$) were also very similar, indicating that the two groups were equivalent in academic performance prior to the treatment (See Table 2)

Table 2: Showing the Pretest Mean and SD of Students' Mathematics Anxiety & Academic Performance by Groups before the Treatment.

Group	Academic performance		Mathematics anxiety	
	Mean	SD	Mean	SD
Control	5.98	2.33	32.80	4.22
Experimental	5.81	2.39	32.85	4.74
Total	5.91	2.35	32.25	4.48

Furthermore, the efficacy of the CTCA on students' mathematics anxiety and academic performance was evaluated using posttest anxiety and posttest academic performance scores. Following the treatment, the posttest means on the anxiety measure for both the experimental and control groups were compared. The results showed that the control group had a higher mean level on anxiety measure ($M=16.31, SD = 2.79$), when

compared to the experimental group (M=11.28, SD = 2.36). This shows that the experimental group taught with a culturo-techno-contextual approach had a reduced anxiety level when compared with their counterparts taught with the traditional method. See Table 3. On the academic performance measure, the experimental group has recorded higher mean scores (M = 20.72, SD = 3.26) than the control group (M = 13.71, SD = 3.81).

Table 3: Showing the Mean and SD of Students' Mathematics Anxiety & Academic Performance by Groups after the Treatment.

Group	Academic performance		Mathematics anxiety	
	Mean	SD	Mean	SD
Control	13.71	3.81	16.31	2.79
Experimental	20.72	3.26	11.28	2.36
Total	16.88	4.98	14.03	3.61

Despite differences in the mean scores on both academic performance and anxiety measures, the data were entered into a MANCOVA with two dependent variables: academic performance and anxiety. The results from MANCOVA showed that the Pillai's Trace attained significant $F(2, 90) = 91.29, p < .05$. The univariate Fs associated with achievement $F(1, 91) = 93.344, p < .05$ and anxiety $F(1, 91) = 87.042, p < .05$ measures both attained statistical significance, respectively. Hence, the null hypothesis stating that treatment has no significant effect on students' anxiety and academic performance was rejected.

Table 3: Showing the Summary of Multivariate Test Statistics for Group Effect.

Group	Pillai's Traces	.67	91.29 ^b	2.00	90.00	.00	182.57	1.00
-------	-----------------	-----	--------------------	------	-------	-----	--------	------

Table 4: Table 4 showing analysis of between-subjects effects for group differences.

Source	Dependent Variable	Type III Sum of Squares	Df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power
Corrected Model	Posttest Anxiety	600.32a	3	200.11	29.06	.00	87.18	1.00
	Posttest Achievement	1211.39b	3	403.78	32.39	.00	97.18	1.00
Intercept	Posttest Anxiety	2555.80	1	2555.80	371.18	.00	371.18	1.00
	Achievement	2996.70	1	2996.70	240.4	.00	240.40	1.00
Pretest Anxiety	Posttest Anxiety	3.79	1	3.79	.55	.46	.55	.11
	Achievement	.783	1	.78	.063	.80	.063	.057
Pretest Achievement	Posttest Anxiety	2.04	1	2.0	.297	.59	.297	.084
	Achievement	54.95	1	54.95	4.41	.04	4.40	.55
Group	Posttest Anxiety	599.33	1	599.33	87.04	.00	87.042	1.00
	Achievement	1163.56	1	1163.56	93.34	.00	93.34	1.00
Error	Posttest Anxiety	626.58	91	6.89				
	Achievement	1134.34	91	12.47				
a. R Squared = .49 (Adjusted R Squared = .47)								
b. R Squared = .52 (Adjusted R Squared = .50)								
c. Computed using alpha = .05								

5. DISCUSSION

The primary objective of this study was to examine the feasibility of the Culturo Techno Contextual Approach in reducing students' anxiety and enhancing academic performance in trigonometry. The findings indicated that students who were taught trigonometric concepts such as angle of elevation and angle of depression using this approach experienced significantly lower levels of anxiety and achieved higher academic performance than those exposed to the conventional lecture method. These results underscore the effectiveness of the Culturo Techno Contextual Approach in creating an engaging and supportive learning environment that promotes active participation and facilitates meaningful understanding of mathematical concepts. Collectively, the study provides empirical support for integrating culturally relevant,

technology-driven pedagogies into mathematics instruction to improve students' affective and cognitive learning outcomes.

These findings are consistent with earlier studies by Allename et al. (2022), Oladejo et al. (2021), and Onowugbeda et al. (2023), which reported that the effectiveness of the Culturo Techno Contextual Approach across various science subjects contributes to reduced learning anxiety. The present study further reinforces the argument that instructional strategies grounded in culturally relevant pedagogy can significantly enhance both affective and cognitive learning outcomes.

The effectiveness of the Culturo Techno Contextual Approach may be attributed to its emphasis on linking academic content with students' cultural backgrounds, indigenous knowledge, and real-life experiences. Trigonometry is often perceived as abstract and difficult; however, integrating

cultural elements into this approach enabled students to develop a more meaningful, contextually grounded understanding of key concepts. This supports the positions of Abdulhadi et al. (2023), Agbanimu et al. (2025), Brown et al. (2019), Ige et al. (2025), Ladson-Billings (1995, 2021), Odekeye et al. (2025), Okebukola et al. (2022), and Onowugbeda et al. (2024). Also, Peter et al. (2025) found that students demonstrate higher levels of motivation and improved learning outcomes when instruction incorporates culturally relevant strategies and contextualised examples. Ademola et al. (2023) reported that CTCA enhanced students' retention of nuclear chemistry concepts and found no significant differences by gender or interaction effects. Awaah et al. (2023) showed that CTCA was effective in improving entrepreneurship education in Ghana.

Furthermore, all these show that the cultural dimension of the Culturo Techno Contextual Approach facilitated students' ability to relate trigonometric concepts to familiar experiences such as measuring height and distance, observing slopes, and applying ratios in everyday contexts. This contextualization not only enhanced conceptual understanding but also reduced anxiety associated with learning abstract mathematical ideas. This finding aligns with Gbamanja's (2014) assertion that the use of cultural knowledge and locally available resources enhances African learners' understanding of scientific concepts. Collectively, these results highlight the critical role of culturally responsive instruction in promoting student engagement, conceptual clarity, and overall academic success.

By connecting contextual examples to the concepts being learned, this approach enables students to recognise and value their own contributions while drawing on relevant real-life experiences, including indigenous knowledge shared by community resource persons prior to classroom instruction. Such engagement fosters a sense of ownership and relevance in the learning process, thereby strengthening conceptual understanding. This finding is consistent with Vygotsky's (1978) sociocultural theory, which posits that knowledge is constructed through active engagement and social interaction within a cultural context.

In addition, some students reported accessing instructional content on online platforms before classroom activities. This integration of technology represents another important dimension of the learning process, as it supports the development of prior knowledge and prepares students for more meaningful classroom engagement. This observation

aligns with the findings of Ajayi et al. (2023), Onowugbeda (2025), Odekeye et al. (2025), Oladejo et al. (2025), Ugwuoke et al. (2024), and Peter et al. (2025), which indicate that the incorporation of technology in instruction facilitates access to digital resources such as YouTube and other educational videos. Such resources help simplify complex concepts, enhance students' readiness to learn, and promote more productive teacher-student interaction during classroom instruction.

Mathematics is inherently embedded within cultural contexts, as students bring diverse experiences and prior knowledge that shape their understanding and foster emotional connections to learning. One of the key components of the Culturo Techno Contextual Approach is its emphasis on group and cooperative learning, which contrasts with the conventional lecture-based approach characterised by one-way communication (Puspitarini et al., 2021). In traditional settings, limited opportunities for participation may lead to poor comprehension and the development of negative attitudes, thereby increasing learning anxiety. In contrast, the Culturo Techno Contextual Approach provides learners with opportunities to actively express their ideas, share reasoning, and engage in collaborative problem-solving within their groups. This process enhances communication skills, promotes a sense of responsibility, and encourages active participation in the learning process.

The findings of this study, in conjunction with existing literature, suggest that the Culturo Techno Contextual Approach has strong potential to improve students' understanding across STEM disciplines, as instruction is grounded in the sociocultural realities of the learners. This position is supported by Di Natale et al. (2020) and García Martínez et al. (2019), who emphasised that contextualised learning enhances both comprehension and retention. By situating learning within familiar contexts, students are better able to internalise abstract concepts and apply them meaningfully.

The consistent application of culturally and contextually responsive teaching strategies can significantly reduce students' anxiety while improving academic performance. Such approaches enable learners to deliberately connect indigenous knowledge and cultural practices with formal academic content. As noted by Chang and Brickman (2018), collaborative learning environments promote deeper understanding by allowing students to draw on diverse perspectives and experiences. This process further facilitates the retrieval and

application of relevant indigenous knowledge, thereby enhancing students' overall comprehension and engagement in mathematics learning.

5.1 Theoretical and Practical Contributions

The findings of this study identify the urgent need to shift the teaching and learning of mathematics concepts, such as trigonometry, away from traditional approaches and toward more inclusive, culturally responsive, and technologically integrated approaches. The Culturo-Techno-Contextual Approach components provide a framework that connects students' indigenous experiences and the dynamic, application-oriented nature of mathematical concepts. Specifically, the study showed that teachers who used culturally based teaching strategies, such as CTCA, provided a strong nexus between classroom instruction and students' socio-cultural experiences. Although the study's findings may not be generalisable due to the sample size, the implications of this result can significantly enhance teaching instruction. The government and policymakers should incorporate indigenous knowledge, with contextual examples, into the national educational policy. CTCA can be developed into a teaching strategy toolkit for African teachers, and, more importantly, continuous professional development, training, and workshops should be encouraged to equip educators with the knowledge and skills to implement CTCA. Curriculum developers and implementers should be equipped with robust tools for assessing diverse cultural practices while simultaneously promoting the systematic integration of such strategies into instructional processes.

5.2 Limitations and recommendations for further research

The study was limited to investigating the efficacy of CTCA on a single topic: trigonometry, a concept in secondary school mathematics widely recognised as

difficult for students and teachers. The study involved a relatively small number of participants, and the intervention was similarly short. The researchers acknowledge that these factors represent significant limitations and may, to some extent, limit the generalizability of the findings.

Nevertheless, the researchers recommend that further research be conducted in Nigeria and in other regions within and outside Africa to examine the effectiveness of this strategy on other challenging concepts in mathematics and other STEM subjects. Such research should utilise a larger sample and a longer intervention period. Furthermore, the researcher recognises that another limitation of the current study is its reliance solely on quantitative data. Further study adopting a mixed-methods approach, combining both quantitative and qualitative data, would provide a more comprehensive understanding of the treatment's true effectiveness.

5.3. Conclusion

Through the findings of this study, the researchers concluded by suggesting that using a culturo-techno-contextual approach – a pedagogy that is both culturally relevant and context-specific will be effective for reducing students' anxiety and improving their academic performance with topics perceived as difficult. This study also provides deep insight into the importance of collaborative learning and group activities. Encouraging students from diverse cultural backgrounds to interact with one another also improves their communication skills and critical reasoning. Anxiety stems most from a lack of confidence, which affects students' performance. To mitigate this, teachers and educators should foster an inclusive learning environment that encourages participation, provides opportunities for collaboration, asks questions and engages students actively in the learning process.

ACKNOWLEDGMENT: The authors express their sincere appreciation to all the students, teachers, and school authorities for their support and cooperation throughout this study.

FUNDING: There was no record of financial support for this study.

REFERENCES

- Abdulhadi, M., Awaah, F., Ekwam, E. O., & Heloo, E. S. (2023). The culturo-techno-contextual approach and students' understanding of computer science education in a developing economy. *Journal of Research in Innovative Teaching & Learning*, 17(3) 490-504
- Abdulrahim, N. A., & Orosco, M. J. (2019). Culturally responsive teaching with Latino English learners with mathematics learning disabilities. *The SAGE Handbook of Inclusion and Diversity in Education*, 276. <https://doi.org/10.4135/9781526470430.n24>
- Ademola, I. A., Oladejo, A. I., Gbeleyi, O. A., Onowugbeda, F. U., Owolabi, O. L., Okebukola, P. A., ... Uhuegbu,

- S. I. (2023). Impact of culturo-techno-contextual approach (CTCA) on learning retention: A study on nuclear chemistry. *Journal of Chemical Education*, 100(2), 581–588. <https://doi.org/10.1021/acs.jchemed.2c00661>
- Agbanimu, D. O., Okebukola, P. A., Onowugbeda, F. U., Peter, E. O., Oladejo, A. I., Gbeleyi, O. A., & Ademola, I. A. (2025). Mitigating difficulty in computer studies through culturo-techno-contextual approach. *The Journal of Educational Research*, 118(2), 147-155. <https://doi.org/10.1080/00220671.2025.2454673>
- Allename, F. A., Agbanimu, D. O., Onowugbeda, F. U., Okebukola, P. A., Peter, E. O., ... Awaah, F. (2022). Underachievement in difficult concepts in Biology: Can CTCA be the way out? [Conference paper]. NARST 95th Annual International Conference: Unity and Inclusion for Global Scientific Literacy: Invite as a Community. Unite as a Community, Vancouver, British Columbia.
- Amaravathi, M., & Kanagathara, S. (2021). An empirical analysis of anxiety and its effect on academic performance
- Arhin, J., & Hokor, E. K. (2021). Analysis of high school students' errors in solving trigonometry problems. *Journal of Mathematics and Science Teacher*, 1(1),1-16. <https://doi.org/10.29333/mathsciteacher/11076>
- Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current directions in psychological science*, 11(5), 181-185. <https://doi.org/10.1111/1467-8721.00196>
- Awofala, A. O., & Lawani, A. O. (2020). Examining the efficacy of co-operative learning strategy on undergraduate students' achievement in mathematics. *International Journal of Pedagogy and Teacher Education*, 4(1), 59-82. <https://doi.org/10.20961/ijpte.v4i1.33402>
- Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, 147(2), 134–168. <https://doi.org/10.1037/bul0000307>
- Bello, M., & Hussaini, A. M. (2023). Effects of computer-based instruction on students' performance and retention in trigonometry among senior secondary schools in SOKOTO STATE, NIGERIA. *Rima*, 2(2).
- Biggs, B. K., Sampilo, M. L., & McFadden, M. M. (2011). Peer relations and victimisation in adolescents with social anxiety disorder
- Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J. M., Szűcs, D., & Mammarella, I. C. (2022). Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychology Review*, 34, 363–399. <https://doi.org/10.1007/s10648-021-09618-5>
- Chang, Y., & Brickman, P. (2018). When group work doesn't work: Insights from students. *CBE – Life Sciences Education*, 17(3), ar52. <https://doi.org/10.1187/cbe.17-09-0199>
- Cruz, A. F. P., Pereira, W. D. S., Ribeiro, N. G., Sousa, J. N., Macedo, M. T. S., Baldo, T. D. O. F., & Baldo, M. P. (2026). Anxiety in the academic environment: impacts on quality of life and well-being of university students. *International Journal of Educational Research*, 136, 102916. <https://doi.org/10.1016/j.ijer.2025.102916>
- Di Natale, A. F., Repetto, C., Riva, G., & Villani, D. (2020). Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research. *British Journal of Educational Technology*, 51(6), 2006-2033. <https://doi.org/10.1111/bjet.13030>
- Egara, F. O., & Mosimege, M. (2025). Reducing mathematics anxiety among Nigerian students using rational emotive behaviour therapy: A randomised control trial. *School Psychology International*, 46(5), 542-562. <https://doi.org/10.1177/01430343251376777>
- García-Martínez, I., & A. Martín-Romera. 2019. "Promoting the pedagogical coordination through the middle leadership in secondary education. A systematic review." *Bordón. Revista De Pedagogía* 71 (2): 55–70. <https://doi.org/10.13042/bordon.2019.67324>
- Gay, G. (2018). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.
- Gbamanja, S. P. T. (2014). Promoting science education in West Africa: A case study from Sierra Leone. *Journal of Science Education and Technology*, 23(4), 451- 460. <https://doi.org/10.1007/s10956-014-9513-0>
- Gbeleyi, O., Okebukola, P. A., Ademola, I., Onowugbeda, F. U., Awaah, F., Peter, E. O., ...
CTCA on students' achievement and critical thinking in computer studies. paper presented at NARST 95th annual international conference: unity and inclusion for global scientific literacy: invite as a community. unite as a community, Vancouver, British Columbia.
- Gopalan, A., & Tyagi, H. (2020). How reliable are test numbers for revealing the COVID-19 ground truth and

- applying interventions?. *Journal of the Indian Institute of Science*, 100(4), 863. <https://doi.org/10.1007/s41745-020-00210-4>
- Hopko, D. R., Mahadevan, R., Bare, R. L., & Hunt, M. K. (2003). The abbreviated math anxiety scale (AMAS): construction, validity, and reliability. *Assessment*, 10(2), 178-182. <https://doi.org/10.1177/1073191103010002008>
- Hooda, M., & Saini, A. (2017). Academic anxiety: An overview. *Educational Quest*, 8(3), 807-810.
- Ige, A., Onowugbeda, F., Mustapha, A., Ogundowole, A., Gbeleyi, O., Olayanju, M., & Armah, M. (2025). Biology Reimagined: A test of culturo-techno-contextual approach (CTCA) in Boosting Students' Achievement. *Journal of Educational Sciences*, 9(1), 1-25.
- Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving schools*, 19(3), 267-277. <https://doi.org/10.1177/1365480216659733>
- Luzano, J. F. (2025). Culturally-responsive mathematics teaching strategies in the contemporary academic tapestry: A scoping review. Available at SSRN 5473966. <https://doi.org/10.2139/ssrn.5473966>
- McCurdy, B. H., Scozzafava, M. D., Bradley, T., Matlow, R., Weems, C. F., & Carrion, V. G. (2023). Impact of anxiety and depression on academic achievement among underserved school children: evidence of suppressor effects. *Current Psychology*, 42(30), 26793-26801. <https://doi.org/10.1007/s12144-022-03801-9>
- Mirawdali, S., Morrissey, H., & Ball, P. (2018). Academic anxiety and its effects on academic performance. <https://doi.org/10.33704/1178-000-020-014>
- McCurdy, B. H., Scozzafava, M. D., Bradley, T., Matlow, R., Weems, C. F., & Carrion, V. G. (2023). Impact of anxiety and depression on academic achievement among underserved school children: evidence of suppressor effects. *Current Psychology*, 42(30), 26793-26801. <https://doi.org/10.1007/s12144-022-03801-9>
- Namkung, J. M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research*, 89(3), 459-496. <https://doi.org/10.3102/0034654319843494>
- Obeng, B. A., Banson, G. M., Owusu, E., & Owusu, R. (2024). Analysis of senior high school students' errors in solving trigonometry. *Cogent Education*, 11(1), 2385119. <https://doi.org/10.1080/2331186x.2024.2385119>
- Odekeye, O. T., Jita, T., Owolabi, T., & Adewusi, M. A. (2025). Revolutionising computer studies pedagogy through cultural, technological connections for improved learning outcomes. *The Journal of Educational Research*, 1-12. <https://doi.org/10.1080/00220671.2025.2540899>
- Odumosu, O., Olisama, O. V., & Areelu, F. (2018). Teachers' content and pedagogical knowledge on students' achievement in algebra. *International Journal of Education and Research*, 6(3), 83-94.
- Okebukola, P. A. (2020). *Breaking barriers to learning: The culture-techno-contextual approach (CTCA)*. Sterling Publishers.
- Okebukola, P. A., Agbanimu, D. O., Awaah, F., Onowugbeda, F. U., ... Imole, S. (2022). Exploring the potency of culturo-techno-contextual approach on achievement of secondary school students in computer networking [conference paper]. NARST 95th Annual International Conference: Unity and Inclusion for Global Scientific Literacy: Invite as a Community. Unite as a Community, Vancouver. British Columbia.
- Oladejo, A. I., Ademola, I., Okebukola, P. A. O., Awaah, F., Agbanimu, D., Onowugbeda, F., ... Odekeye, T. (2021, April). In Search of New Tools for Meaningful Learning in Chemistry –We Stumbled on Culturo-Techno-Contextual Approach. In Presented at the 94th Annual Conference of NARST.
- Oladejo, A. I., Okebukola, P. A., Nwaboku, N., Kola-Olusanya, A., Olateju, T. T., Akinola, V. O., ... & Ogunlade, I. (2023). Face-to-Face and blended: Two pedagogical conditions for testing the efficacy of the culturo-techno-contextual approach on learning anxiety and achievement in chemistry. *Education Sciences*, 13(5), 447 <https://doi.org/10.3390/educsci13050447>
- Oladejo, A. I., Olateju, T. T., Okebukola, P. A., Sanni, R., Akintoye, H., Onowugbeda, F., ... & Adam, U. (2025). Breaking barriers to meaningful learning in STEM subjects in Africa: A systematic review of the culturo-techno-contextual approach. *Sustainability*, 17(5), 2310. <https://doi.org/10.3390/su17052310>
- Onowugbeda, F. U., Agbanimu, D. O., Okebukola, P. A., Ibukunolu, A. A., Tokunbo Odekeye, O., & Olori, O. E. (2023). Reducing anxiety and promoting meaningful learning of biology concepts through a culturally sensitive and context-specific instructional method. *International Journal of Science*

- Education, 45(15), 1303-1320. <https://doi.org/10.1080/09500693.2023.2202799>
- Onowugbeda, F. U., Okebukola, P. A., Agbanimu, D. O., Ajayi, O. A., Oladejo, A. I., Awaah, F., ... & Ige, A. M. (2024a). Can the culturo-techno-contextual approach (CTCA) promote students' meaningful learning of concepts in variation and evolution? *Research in Science & Technological Education*, 42(2), 395-411. <https://doi.org/10.1080/02635143.2022.2084060>
- Onowugbeda, F. U., Okebukola, P. A., Ige, A. M., Lameed, S. N., Agbanimu, D. O., & Adam, U. A. (2024b). A cultural, technological, and contextual pedagogy to enhance retention of biology concepts. *The Journal of Educational Research*, 117(2), 49-60.
- Onowugbeda, F. U., Ige, A. M., Ayoola, E. A., Adam, U. A., Peter, E. O., & Agbanimu, D. O. (2025). Culturally relevant pedagogy laced with technological and contextual elements to lower anxiety and enhance retention of biology concepts. *Research in Science & Technological Education*, 1-22. <https://doi.org/10.1080/02635143.2025.2596237>
- Parker, C., Shalev, D., Hsu, I., Shenoy, A., Cheung, S., Nash, S., ... & Shapiro, P. A. (2021). Depression, anxiety, and acute stress disorder among patients hospitalised with COVID-19: a prospective cohort study. *Journal of the Academy of Consultation-Liaison Psychiatry*, 62(2), 211-219. <https://doi.org/10.1016/j.psych.2020.10.001>
- Pekrun, R., & Linnenbrink-Garcia, L. (2012). Academic emotions and student engagement. In *Handbook of research on student engagement* (pp. 259-282). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4614-2018-7_12
- Pekrun, R. (2024). Control-value theory: From achievement emotion to a general theory of human emotions. *Educational Psychology Review*, 36(3), 83. <https://doi.org/10.1007/s10648-024-09909-7>
- Peter, E. O., Onowugbeda, F. U., Okebukola, P. A., Agbanimu, D. O., Oladejo, A. I., & Gbeleyi, O. A. (2025). Integrating culture and context: Enhancing students' performance in computer networking. *The Journal of Educational Research*, 1-10.
- Puspitarini, D. (2022). Blended learning sebagai model pembelajaran abad 21. *Ideguru: Jurnal Karya Ilmiah Guru*, 7(1), 1-6. <https://doi.org/10.51169/ideguru.v7i1.307>
- Reichardt, C. S. (2009). Quasi-experimental design. *The SAGE handbook of quantitative methods in psychology*, 46-71.
- Rigney, L. I. (2023). Culturally responsive pedagogies: Australian colonial logic of the centre and Aboriginal refusal. In *Working with theories of refusal and decolonisation in higher education* (77-92). Routledge. <https://doi.org/10.4324/9781003367314-8>
- Samuel, T. S., & Warner, J. (2021). "I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. *Community College Journal of Research and Practice*, 45(3), 205-222. <https://doi.org/10.1080/10668926.2019.1666063>
- Suherman, R., Vebrian, N. A., Fauzan, T. M., Sari, N., Putri, N. I., & Priadi, M. (2021). SQ3R method assisted by an ethnomathematics-oriented student worksheet: The impact of mathematical concept understanding. *Journal of Physics: Conference Series*, 1796(1), 012059. <https://doi.org/10.1088/1742-6596/1796/1/012059>
- Supriyanto, D. H., Firdaus, F. M., Rahmawati, A. D., Maulyda, M. A., Prasetyo Mahfud, A. Y., Paais, R. L., ... & Berty, Y. N. (2026). Examining the role of cultural knowledge in the relationship between realistic learning and students' mathematics achievement: A multifaceted analysis. *Scientific Culture*, 12. DOI: 10.5281/zenodo.122.126222
- Torre, D., Chamberland, M., & Mamede, S. (2023). Implementation of three knowledge-oriented instructional strategies to teach clinical reasoning: self-explanation, a concept mapping exercise, and deliberate reflection: AMEE Guide No. 150. *Medical Teacher*, 45(7), 676-684. <https://doi.org/10.1080/0142159x.2022.2105200>
- Ugwuoke, U., Okebukola, P., Emmanuel, E., Onowugbeda, F., & Onuorah, B. (2024). Fostering positive instruction of software development cycle through a culturally responsive pedagogy. *The Journal of Educational Research*, 117(6), 387-396.
- Ugwuoke, U., Tetteh, A., Okebukola, P., & Ogonenwe, J. (2025). Enhancing ICT retention through indigenous pedagogy. *Discover Education*, 4(1), 512. <https://doi.org/10.1007/s44217-025-00962-0>
- Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press. <https://doi.org/10.1080/00220671.2024.2324714>

<https://doi.org/10.1080/00220671.2025.2590508>

<https://doi.org/10.1080/00220671.2024.2426526>

Abdulazeez, H. T. (2022, March 27-30). Heartbreak for underachievement: Perspectives of

Nanmumpuni, H. P., & Retnawati, H. (2021, February). Analysis of senior high school students' difficulty in resolving trigonometry conceptual problems. In *Journal of Physics: Conference Series* (Vol. 1776, No. 1, p. 012012). IOP Publishing. <https://doi.org/10.1088/1742-6596/1776/1/012012>

<https://doi.org/10.1108/JRIT-12-2022-0087>

Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: Aka the remix. *Harvard Educational Review*, 84(1), 74–84. <https://doi.org/10.17763/haer.84.1.p2rj131485484751>