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Teaching Conservation of Natural Resources with Culturally Responsive and Context Specific Environment: The Stance of Cultro-Techno-Contextual Approach

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A B S T R A C T

A key reason for students' poor performance in biology is the lack of connection between their indigenous knowledge, cultural context, and local experiences and the subject's teaching. This study explored the efficacy of the culture-techno-contextual approach (CTCA) to enhance the achievement and attitudes of secondary school students in biology. A quasi-experimental group design was employed. The study involved 135 biology students from two intact classes in schools within an education district. The treatment group (CTCA) had 67 students and the control group had 70 students. The instruments used for data collection were the Conservation of Natural Resources Achievement Test (0.70) and the Conservation of Natural Resources Attitude Questionnaire (r= 0.78). Data were analyzed using MANCOVA, having satisfied the parametric assumptions. The findings revealed a statistically significant difference in the achievement and attitudes of students taught using the culture-techno-contextual approach compared to those in the control group ($F = 16.87$; $p < 0.01$). CTCA had no statistically significant impact on students in the experimental group based on gender ($F = 16.87$; $p < 0.01$). It was concluded that the CTCA is an effective tool for enhancing students' achievement and attitudes in biology.

1. Introduction

For decades, Nigeria, like many other African nations, has inherited a rich STEM education legacy heavily influenced by Western ideologies rooted in the colonial era (Mutegi, 2013; Nagala, 2013). However, these Western approaches have often proven unsustainable within Nigeria's intricate socio-cultural landscape, disregarding the wealth of indigenous knowledge systems that thrived before colonisation (Anamuah-Mensah, 2020; Okebukola et al., 2016). This disconnect

has undermined the integration of local cultural heritage into education, particularly in the teaching of science subjects. Despite numerous efforts to reform biology teaching methods, challenges persist in fostering meaningful understanding, particularly in areas such as environmental conservation and natural resource management. While instructional strategies such as outdoor activities, guided inquiry, practical approaches, and field trips have shown potential to enhance active learning, they often fail to address the deeper cultural and contextual disconnections. These gaps underscore the need for the Culturo-Techno-Contextual Approach (CTCA), a pedagogical model designed to bridge these divides by integrating local cultural relevance into science education.

When employing CTCA in the classroom, students are encouraged to relate each lesson to their indigenous knowledge or cultural practice. This approach impacts a sense of relevance to their daily lives, debunking the mystique surrounding scientific concepts in today's digital age, technology plays a crucial role in education, learners now have access to a wide range of digital tools and resources, making them more tech-savvy than ever before. Research shows that students have a strong affinity for modern technologies like YouTube, Wikipedia, WhatsApp and Facebook which offers valuable information and collaboration opportunities (Al-Aswan et al 2013, Vargi et al, 2021) CTCA recognizes and embraces student's enthusiasm for technology, utilizing its tools to enhance meaningful learning experiences. Rather than being viewed as a distraction, technology is seen as an empowering force that creates a connected and engaging learning environment. CTCA also fosters collaboration and communication through video conferencing and instant messaging, connecting learners globally and promoting diverse perspectives and cultural understanding. Student's locational context plays a crucial role in their cognitive constructs of learning when used to exemplify the concepts being taught (Onowugbeda et al, 2022 b). Teaching approach that enables students to explore their immediate surroundings and establish connections between their daily lives and classroom activities has been found to facilitate the meaningful acquisition of STEM concepts (Adam et al. 2025).

CTCA was developed to address the failure of "one-size-fits-all" teaching methods, which have often been based on strategies that worked well in Western contexts but did not yield effective results in Nigeria (Okebukola et al., 2016; Ogunbanwo, 2019; Egerue, 2019). Despite the exploration of various educational methods to improve conservation education in secondary schools, there has been limited focus on CTCA, particularly in its application to the conservation of natural resources in biology education (Adekoya, 2023). The CTCA provides a framework that goes beyond traditional methods, which often fail to engage students meaningfully. It breaks down barriers such as the fear of complex educational concepts, lack of teaching resources, and misconceptions about the accessibility of education for all students (Abdulhadi et al., 2023; Adekoya, 2023; Awaah et al., 2021).

This approach involves the fusion of three key elements: cultural context, technology mediation, and local context (see Figure 1). Cultural context refers to

the deep immersion of learners in the culture they belong to, while technology mediation reflects the growing reliance on technology to aid teaching and learning. The local context pertains to the unique identity of each school, with an emphasis on using local examples and case studies to make learning more relatable and effective (Okebukola, 2018). Through this integration, the CTCA approach fosters a deeper connection between students and the scientific concepts being taught, especially in topics like conservation of natural resources.

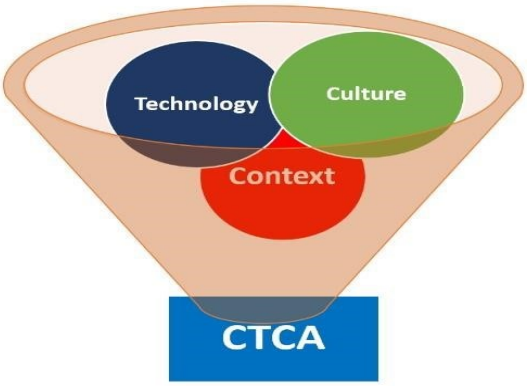

Figure 1. The CTCA Framework *Source (Okebukola, 2015)*

The Culturo-Techno Contextual Approach (CTCA) aims to foster such attitudes by integrating students' cultural backgrounds and local contexts into the learning process, making the content more relatable and engaging. When students connect scientific concepts, like conservation, to their own experiences and community issues, they are more likely to develop a sense of ownership and responsibility, which further enhances their academic performance and long-term commitment to environmental stewardship. This study explores how the integration of local knowledge, cultural practices, and technological tools in the CTCA can influence both students' academic achievement and their attitudes towards conservation education, promoting a more meaningful and transformative learning experience. Evidence abound show that CTCA significantly enhanced the students' achievement (Oladejo et al.,2021; Okebukola et al.,2015; Adam et al.; 2021; Gbeleyi et al.;2021) attitude (Agbanimu et al.,2021; Akintola, 2019; Adam, 2019) critical thinking ability (Gbeleyi,2021), has no gender effects (Oladejo et al., 2020) and it encouraged students' classroom participation and interest (Okebukola *et al.*, 2016; Oladejo et al., 2020; Adeola,2020; Hungbeji,2020; Sholanke,2020).
Achievement is a variable that plays significant role in shaping students learning outcomes in science. It reflects ability of students to meet learning objectives and demonstrate their understanding of biological concepts. Many factors such as teaching methods, resources available, prior knowledge influence achievement of students in biology. Achievement measures how well students can transfer and apply their learning to solve practical problems, particularly those related to the conservation of natural resources (Onowugbeda, 2024). Numerous studies on strategy that could support meaningful learning and improve student's learning outcomes are available in the literature. In literature, the moderating variables of attitude and gender are interconnected to influence a significant role in shaping students' outcomes in secondary school biology. Understanding their interplay is

essential for designing effective teaching strategies that address needs of the learners. Attitudes toward biology, encompassing students' feelings, beliefs, and perceptions are equally of significance. A positive attitude motivates students to engage actively with the subject, see its relevance to their lives, and develop a genuine interest in related fields. Conversely, negative attitudes can lead to disengagement and underperformance. Factors that shape students' attitudes include the teaching style, the perceived difficulty of biology, the extent to which practical activities are incorporated, and the subject's connection to their real-world experiences (Adam et al. 2024d).

Conservation of natural resources is a vital issue in the context of global environmental challenges. It involves protecting and managing resources such as air, water, soil, plants, animals, minerals, and energy to ensure their sustainability for future generations. Effective teaching of this concept in biology education is crucial, especially in Nigeria, where issues like deforestation, soil erosion, and water scarcity are prevalent. This study aims to explore how the CTCA can enhance the teaching of conservation by linking students' learning to local environmental issues and cultural practices. Two research questions guided the study:

1. Is there a significant difference in the achievement and attitude of students taught conservation of natural resources using CTCA and lecture method?
2. Will there be a significant difference in the achievement and attitude of male and female students taught conservation of natural resources using the CTCA?

Hypotheses

Two null hypotheses were tested at .05 level of significance:
There is no statistically significant difference in the achievement and attitude of students taught conservation of natural resources using the CTCA and lecture method. There will be no statistically significant difference in the achievement and attitude male and female students taught conservation of natural resources using the CTCA.

Theoretical Frameworks/Review

This current study is anchored on Okebukola Eco-technocultural theory of CTCA and Lev Vygosky social constructivism (1896 – 1934). Lev Vygosky's socio-cultural learning theory emphasizes the significance of interactions society and culture in learning (Mahn & John-Steiner, 2012). Meaningful understanding has become conceptualized as an advance level of learning outcome to learners primarily by teachers during teaching learning process however, Okebukola's **Eco-Technocultural Theory** forms the foundation for the **Culturo-Techno Contextual Approach** by integrating four key principles: **ecology, culture, technology**, and **humor**. These principles act as activation energies that support meaningful learning. Each step of CTCA reflects these ideas, ensuring that learning is not only relevant to students' cultures and contexts but also enhanced

by technology and humor, making the experience both engaging and cognitively stimulating.

According to Lev Vygosky, learning occurs through the support and guidance others provide, highlighting the theory social aspect, it emphasizes the role of social interaction both within the family unit and with individuals who possess greater knowledge and expertise in society, as a foundation for a child's acquisition of knowledge and behaviors that are meaningful and applicable within their social context. Lev Vygosky believed social interaction greatly influenced cognitive development. Vygosky suggested cognitive processed were relevant to society as contained in CTC approach amalgam and not universal as Jean Piaget believed Vygosky's socio-cultural theory rested on two main principles, more knowledgeable than other (MKO) and zone of proximal Development (ZPD). The MKO refers to an individual who possesses a higher level of knowledge or expertise in a specific subject matter, task or concept than the learner. This knowledgeable person serves as a guide or mentor, offering support and scaffolding to facilitate the learners understanding and skill development (Muhayimana, 2017 &Vygosky, 1978).

2. Methodology

The quasi-experimental design, a pre-test and post-test non-equivalent group design was employed in this study. Two intact classes were used, one school served as the experimental group (where CTCA was implemented) and the other school served as a control (where the teacher used the lecture method). The two schools are located in different area to avoid imitation of treatment. The researcher used Intact classes because it was not possible to randomize the students to experimental and groups, going by this, we adhered to the school policies by not disrupting the school activities.

The study was conducted in two randomly selected senior secondary schools within Education District V, Lagos State. Lagos state is located in the South-Western part in Nigeria, this region is predominantly occupied by Yoruba ethnic group. All the secondary school schools in Lagos state are categorized into six education districts based on their geographical locations and for administrative control. A total of 135 Senior Secondary School I (10^{th} grade) students participated in the study, the experimental group had 67 students (35 males and 30 females), and the control group had 70 students (40 males and 30 females). About 68% of the total students were from the Yoruba ethnic group, and all participants were proficient in English, ensuring effective communication. Senior secondary I students were selected for their foundational knowledge of ecology and pollution which served as prerequisites for the conservation of natural resources topic, and for their availability during a stable learning period before standardized exam preparations. The conservation of natural resources was chosen for its relevance to sustainable environment and preservation of natural resources, and career pathways, as well as its perceived difficulty. This was supported by reports from WAEC chief examiners (2016, 2019, 2020, and 2024) and surveys on challenging

biology concepts. The timing of the study was optimal, as the students were in a stable learning period and not preparing for major examinations like the West African Examination Council (WAEC) and National Examination Council (NECO) examinations. This stability provided a conducive environment for assessing the impact of the intervention.

Data were collected using two instruments: the Conservation of Natural Resources Achievement Test (CNRAT), Conservation of Natural resources attitude Questionnaire (CNRAQ). The CNRAT, developed to assess students' achievement, was based on the structure and standards of the West African Senior School Certificate Examination (WASSCE) questions. The instrument consisted of 30 multiple-choice items with four options (A–D). Each item carried one point, and the test was designed to be in alignment with the WASSCE curriculum and objectives. To validate the CNRAT, a team of three experienced biology teachers who coordinated and marked WASSCE exams thoroughly reviewed each item for clarity, relevance, and appropriateness. They also ensured that the distractors were plausible but incorrect. The instrument was further validated by two science educators who ensured that the items aligned with lesson plans' content and behavioral objectives.

The reliability of the CNRAT was estimated using the split-half reliability technique. The test was administered to a group of students who shared characteristics similar to those in the study sample but were not part of the actual study. The Spearman-Brown formula yielded a reliability coefficient of 0.70, while the reliability coefficient of CNRAQ is 0.78. With these reliability coefficient indexes; the instruments were found to be reliable for the study.

The intervention process, which lasted for **four weeks**, with both groups receiving 80-minute lessons each week. The teachers in both groups used designated guides: the **Guide on Culturo-Techno Contextual Approach for teachers (GCTCAT)** and the **Guide on Lecture Method (GLMT).** In the first week, students learned about the concept on conservation of natural resources and the parts, the second week focused on the needs for conservation. The third week was used to teach methods of conservation of natural resources and The last week covered the problems of conservation of natural resourses. The CTCA was implemented as follows:

Treatment procedure in the experimental group

The researcher sought for approval from the Lagos state ministry of education, Tutor general of the education district V, and then to the school principals. The school principals introduced the researcher to the class teachers and the biology teachers. Treatment began with administration of pretest to both experimental and control groups. The experimental group was exposed to the CTCA for four weeks of 80 minutes contact duration, while the control group was taught using the traditional lecture method. After the treatment, the participants were post-tested to measure achievement gain in the two groups. The intervention followed the steps below

Step 1: – Pre – Lesson Assignment on cultural practices and web resources related to conservation of natural resources.
The teacher informed the students ahead of the lesson time of the topic to be learned in class. Each student was tasked with two responsibilities: using their mobile phones or other internet-enabled devices to search the web for resources (watch YouTube videos) related to "conservation of natural resources" and reflecting on or making inquiries of their parents, caregivers, siblings and move around their neighborhood to see organisms in their natural environment to have Indigenous knowledge on cultural practices/beliefs associated with the topic.

Step 2: Group Work on the Output Generated in Step 1
The lesson commences in the class with the introduction of the topic by the teacher. The teacher grouped the students into mixed-sex groups, having a maximum of 8 students in a group to share individual findings generated from step 1 (summaries of ideas from watching YouTube and the related cultural practices obtained from the parents and the things they observe themselves). The teacher assigned group leaders from each group who noted the submissions of group members and presented the summary to the whole class. This step ends with the teacher sharing his indigenous knowledge or cultural practices associated with variation with the class.

Step 3: Sprinkle of Humor and Drawing Practical Examples from the Surrounding (Context) of the school
As the lesson progresses, the teacher draws up practical examples within the immediate environment of the school and their neighbourhood to exemplify concepts in the topic and does so with a sprinkle of content-specific humor to make the learning fun. Such examples that can be seen by the students help to consolidate learning and make science real. This stage represents the context (contextual) flavor of the CTCA

Case study 1- conservation of natural resources: In Yoruba land, there are taboos and cultural prohibitions (e.g., not cutting sacred trees or hunting specific animals) play a significant role in conservation. The Yoruba's spiritual beliefs and cultural norms prevent over-exploitation of resources, as breaking these taboos is believed to bring misfortune or divine punishment to whoever violates this norm. This can be related to the concept of *sustainable harvesting* in conservation biology. Students can learn how taboos act as informal conservation laws, ensuring that resources are used responsibly and sustainably (see Figure 2 and 3)

Figure 2. Cultural practice exemplifying the problems of conservation of natural resources

Figure 3. Planting of trees showing the method of conservation of natural resources

Case study 3- Method of Conservation of Natural Resources: The Yoruba regard rivers, lakes, and other water bodies as sacred, and there are cultural restrictions against polluting them (see figure 4). Water sources like the Osun River are protected through religious observances and taboos. This can be linked to the importance of *water conservation* and the protection of aquatic ecosystems. These human activities such as pollution threaten water resources and how local practices can help protect these vital ecosystems. The Yoruba practice of safeguarding sacred water bodies can be discussed in the context of *aquatic resource management*.

Case study 4 – Benefits of conservation: The Yoruba possess extensive knowledge of local plants, animals, and their medicinal uses. They have developed systems for identifying and preserving endangered species, often

through spiritual beliefs or taboos. Students can learn how traditional knowledge contributes to *biodiversity conservation*. This can be related to the role of ethnobotany and indigenous knowledge in the identification and protection of species. modern biologists are increasingly recognizing the value of traditional ecological knowledge in biodiversity conservation.

Figure 4. Cultural practice (appeasing the water body by traditional worshippers) for preservation of resources

Step 4: Teacher Relates the Topic with Cultural Practices and Web Resources

As the lesson progresses, the teacher reminds the class of the relevance of the Indigenous knowledge or cultural practices documented by the groups for meaningful understanding of the concepts. The teacher clarifies possible misconceptions that are associated with cultural beliefs. At this stage, students can ask questions, if any, and the teacher may also wish to evaluate the students.

Step 5: Lesson Ends, and the Teacher Sends a Summary of the Lesson to the Students via WhatsApp

At the close of the lesson, the teacher informed the students that a summary of the lesson would be sent to their phones as a WhatsApp message. The summary was a maximum of 320 characters. The summary of the first lesson was sent by the teacher to all students. After the first lesson, student group leaders were accorded the responsibility of sending such messages after each class. Before the class was dismissed, the teacher informed the students of the topic for the next lesson. As it was done in step 1, the students were informed to reflect on the Indigenous knowledge or cultural practices associated with the next topic

Lesson delivery in the control group

In the control group, for every lesson in the four weeks of implementation, the students were taught “conservation of natural resources” using the following steps;

1. The teacher commenced by reviewing the previous lesson and introducing the new topic of conservation natural resources to the students.
2. The teacher provided explanations of variation concepts, relying on foreign examples and delivering the material without engaging students in discussions or interactive activities.

3. Notes were written on the board by the teacher, and students were required to copy these into their notebooks.
4.The lesson concluded with the teacher summarising the key points and assigning homework, which the students recorded in their notebooks.
5. Lastly, the teacher collected the students' notebooks, marked their work, and returned them.

Data Analysis
The research questions were answered using the mean and standard deviation while inferential statistics of MANCOVA was adopted to test the null hypotheses. To ensure the suitability of MANCOVA, the data were subjected to parametric tests. The statistical techniques were used to assess the effectiveness of the CTCA in enhancing students' attitude and achievement in conservation of natural resources, as well as any gender-based differences in the impact.

3. Results and Discussion

The results obtained from the levene test of homogeneity of variance revealed that the variance is homogeneous among the groups (Achievement = F= 1.05; p> 0.05; Attitude = F= 0.38; p > 0.05). The Kolmogorov-Smirnov test also revealed that the data collected in each group for each of the dependent variables were not significantly different from normal (Achievement= F= 0.16; p> 0.05; Attitude = F= 0.10; p > 0.05)
Research question one examined if there is a significant difference in the achievement and attitude of students taught conservation of natural resources using CTCA and lecture method. The result in figure 5 reveals that after the treatment was implemented across the groups, the CTCA group had a higher mean score on achievement and attitude when compared to the lecture method group (CTCA = 22.53; Lecture = 7.65); and attitude (CTCA = 37.87; Lecture = 13.43).

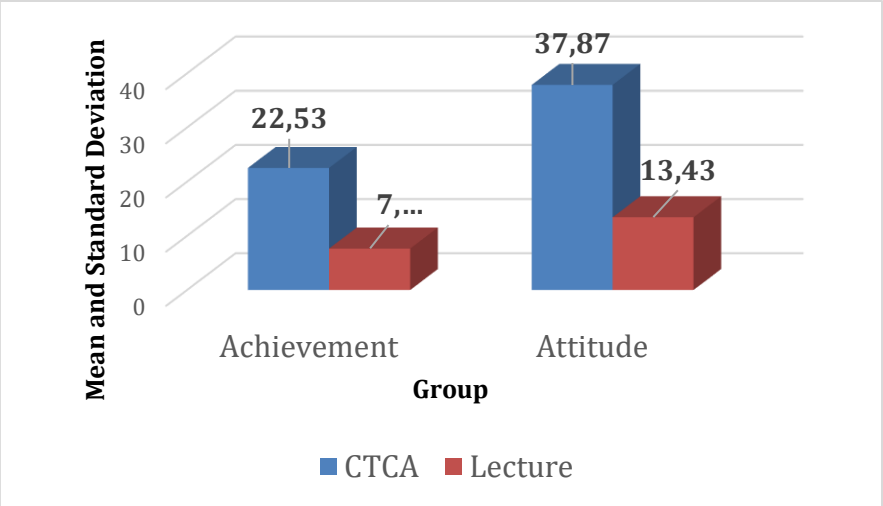

Figure 5. Mean score on achievement and attitude for experimental and control groups

The data was further subjected to inferential statistics. This was achieved by factoring the data into the MANCOVA equation using the pretest as covariate. The essence of the covariate was to draw both groups to the baseline since randomisation was not achieved. Results in Table 1 reveals that there is a statistically that there was a statistically significant difference in performance between the groups in the study (Pillai's trace = 0.38 (F = 16.87; $p < 0.01$). The output of the univariate F (see Table 1) further showed that the observed difference in between the groups in both achievement ($F(2,130) = 15.56$; $p < 0.05$) and attitude ($F(2,130) = 13.58$; $p < 0.05$) attained statistical significance.

Table 1. Univariate F for achievement and attitude

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Teaching strategies	Achievement	156.37	2	78.185	15.56	.01(S)
	Attitude	150.71	2	75.356	13.58	.03(S)
Error	Achievement	1829.65	130	14.074		
	Attitude	2736.83	130	21.053		

The second research question examined if there is a significant difference in the achievement and attitude of male and female students taught conservation of natural resources using the CTCA. Before subjecting the data to F-test as can be seen in Table 3, the descriptive statistics already showed a comparable mean difference between the mean score of the male and the female students in the CTCA group on achievement and attitude (see Table 2).

Table 2. Mean scores and standard deviation of male and female students in the CTCA group

Dependent Variable	Gender	Mean	Standard Deviation	N
Achievement	Male	18.54	3.65	32
	Female	19.87	3.47	35
Attitude	Male	34.65	2.61	32
	Female	35.54	2.45	35

Table 3 revealed that the output of the multivariate (Pillai's trace = 0.01 (F = 0.44; $p = 0.72$) revealed that on each of the measures of achievement ($F(1,131) = 0.38$; $p > 0.05$) and attitude ($F(1,131) = 0.73$; $p > 0.05$), the mean difference between the male and female students did not attain statistical difference

Table 3. Univariate F for achievement and attitude

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Gender	Achievement	5.75	1	5.75	.38	.54(NS)
	Attitude	15.92	1	15.92	.73	.40(NS)
Error	Achievement	1980.27	131	15.12		
	Attitude	2871.62	131	21.92		
Total	Achievement	52310.00	135			
	Attitude	45090.00	135			

Research question one examined whether there is a significant difference in achievement and attitude between students taught conservation of natural resources using CTCA and the lecture method. The mean scores showed that students taught with CTCA outperformed those taught using the lecture method on both achievement (CTCA = 22.53; Lecture = 7.65) and attitude (CTCA = 37.87; Lecture = 13.43). The hypothesis was tested using MANCOVA, revealed a statistically significant difference in favour of the CTCA group. Both achievement and attitude measures had significant univariate F values (achievement $F = 15.56$, attitude $F = 13.58$, $p < .05$). This finding aligns with Adam et al. 2024b; Ademola et al. (2023); Akintoye et al. 2024; Onowugbeda et al. (2022). In this previous works, CTCA was found to promote meaningful learning of STEM concepts among senior secondary school students.

Based on the data supporting our findings in this study, we conjectured that the success story of CTCA in the current study may be attributed to the following action mechanisms in the learning process at the treatment phase. In the CTCA powered class, for each lesson, all students take two pre-lesson assignments (see CTCA step 1). Each student was tasked with two responsibilities: using their mobile phones or other internet-enabled devices to search the web for resources (watch YouTube videos) related to "conservation of natural resources" and reflecting on or making inquiries of their parents, caregivers, siblings on Indigenous knowledge or cultural practices/beliefs associated with the topic. By these activities, many of the students in the CTCA group came to class already primed for learning on two fronts – culture and technology. The indigenous knowledge or cultural practices documented by the students (learning from parents/any other adult) and the lesson videos accessed through the YouTube already provided some level of information about the new topic, thus the students did not come to class blank, a foundation upon which the new learning can lay has already been formed.

Another aspect of the CTCA component, which logically explains the better performance of students in the CTCA groups, is the use of contextual examples in the CTCA class. According to (Okebukola, 2020), the locational context is the unique identity of every school, and it plays a strong role in the examples and local case studies for science lessons. Pobiner et al. (2019) argued that through the use of relevant human examples, even upper primary school students could understand basic evolutionary concepts in biology. He further argues that using relevant examples promotes students' engagement in the classroom and explicitly creates an interactive learning environment. This tenet of the CTC approach, which emphasizes the use of practical examples that are within the learning environment of the students, helps to consolidate knowledge and promote meaningful learning of complex biology concepts.

Research question two explored whether there is a significant difference in achievement and attitude between male and female students taught using CTCA and the lecture method. Our findings revealed that on both dependent variables, no statistically significant difference was found between the male and female students. These findings tally with that of other studies [Oladejo et al. 2024;

Adam et al. 2024c; Awah et al. 2024; Onowugbeda et al. 2024). These studies all took place at different times and locations, yet they all reported to have found no difference in the performance of male and female students sampled. It can be recalled that CTCA operates on a five-step implementation process, it was hypothesized that the active agent, which prompted the observed gender equity in learning and performance, is hiding within these processes. In step 1, all students were saddled with the same tasks: find indigenous knowledge related to topics and visit YouTube for related videos. These assignments were for females the same as for male students in the class; in this study as well as in the studies cited. Based on the sample characteristics, over 70% of the participants were from the same cultural background, the cultural information they fetched was not too different from one another, and because the process of collecting/collating the related cultural practices involved a form of storytelling or narration, the female students were not disadvantaged (Oludipe et al., 2012).

On the use of YouTube for information, there was no difference between the videos available to either party; whatever video lessons the males took, the females too had an equal chance of having the same. YouTube is one of the most visited social media platforms in Nigeria. As of the third quarter of 2020, statista.com reported that 81.6% of internet users in the country visit YouTube, which made it the 3rd most used social media platform in Nigeria behind WhatsApp (another social media agent in this study) and Facebook, whose ratings were 93% and 86.3%, respectively. Given this popularity, several studies in Nigeria had investigated the effect of YouTube on teaching and learning (Abubakar et al. 2022; Alabi et al., 2020). These studies reported no statistically significant difference in the perception of male and female students about the use of YouTube for teaching and learning purposes. Therefore, the use of YouTube videos as a primer for meaningful learning in CTCA is not only proving to be an effective strategy but also gender friendly Notably, and as reported by (Oladejo et al., 2021], since 2015 the literature is showing that teaching–learning strategies that involve the use of modern technologies, social media, mobile phones, and computer simulations are becoming increasingly popular in bridging the long-coming gender difference in students' achievement in secondary school chemistry.

4. Conclusion

The primary aim of this study was to explore a potential solution to the longstanding issue of unsatisfactory performance in biology among secondary school students. By investigating the effectiveness of the Culturo-Techno-Contextual Approach (CTCA), which integrates cultural, technological, and contextual factors into the teaching of biology, the study sought to identify a more inclusive and relevant pedagogy for diverse learners. The results of the study strongly indicate that CTCA significantly improved both the academic achievement of students and their attitudes toward biology, marking a considerable shift from traditional teaching methods.

The findings suggest that CTCA serves as an effective tool in fostering more meaningful learning experiences in biology. By tailoring the pedagogy to students' cultural backgrounds, local contexts, and technological environments, CTCA helps students better relate to the material, making the learning process more engaging and relevant. Moreover, the study revealed that CTCA helped bridge the gender gap in science performance, contributing to a more equitable educational environment. This outcome is particularly important in light of the persistent gender disparities in science education, where males typically outperform females in many contexts. The reduction of such disparities through culturally responsive teaching is a critical step toward achieving gender equity in education.

The success of the experimental group, which benefited from CTCA, demonstrates that this approach not only enhances academic performance but also nurtures a positive attitude toward the subject of biology. Students who engaged with CTCA were more likely to view science as accessible and meaningful, which is a significant factor in fostering lifelong interest in STEM fields. The positive shift in both achievement and attitude suggests that CTCA holds promise not just for improving biology education but also for helping students across various disciplines develop a deeper connection to their studies.

Furthermore, this study aligns with broader educational and development goals, particularly those set out in the African Union Agenda 2063 and the United Nations Sustainable Development Goals (SDGs). Specifically, the findings support SDG4 (Quality Education), which calls for inclusive, equitable, and quality education for all, as well as SDG5 (Gender Equality), which advocates for the reduction of gender disparities in education. The study's impact on narrowing gender gaps in science also indirectly contributes to SDG1 (No Poverty), SDG2 (Zero Hunger), and SDG3 (Good Health and Well-being), since quality education in science can drive future contributions to sustainable development, economic growth, and public health.

In essence, this study reinforces the idea that culturally relevant pedagogy is not just a matter of improving academic outcomes—it is also a crucial step in breaking down the barriers that hinder students' success in science. It demonstrates that by tailoring educational practices to the socio-cultural realities of learners, we can create more equitable and effective learning environments that empower students from diverse backgrounds to succeed in challenging subjects like biology.

The findings also underscore the importance of aligning education systems with the values and needs of the communities they serve. When science education is contextualized to reflect students' cultural backgrounds and technological environments, it becomes more relatable, accessible, and motivating. This, in turn, fosters better learning outcomes and attitudes, helping to equip students with the skills and knowledge they need to contribute meaningfully to their societies and the global community.

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