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DECOLONIZING BIOLOGY CLASSROOMS IN NIGERIA: THE SIGNIFICANCE OF CULTURO-TECHNO-CONTEXTUAL APPROACH

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ABSTRACT
The methods employed in science instruction are experiencing a transformation, with novel approaches like the Culturo-Techno-Contextual Approach (CTCA) emerging as more efficacious variant. This study explored the efficacy of CTCA in improving the achievement of secondary school students in biology. The study employed an explanatory sequential design. The quantitative phase was quasi-experimental, while the qualitative phase was an in-depth interview. A total of 103 senior secondary II students (the equivalent of grade 11) from two purposively selected schools in Lagos State education district V were sampled. The Achievement Test in Tissue and supporting system which had reliability coefficients of 0.8, were the instruments used to collect quantitative data, while the students' perception about CTCA interview guide was used to collect the qualitative data. Both groups had a pretest and posttest using the achievement test; treatment lasted four weeks. Data gathered in the survey were analyzed using ANCOVA since intact classes were used. The result obtained showed that the experimental group (mean for experimental = 10.53; control 6.83; $F(1, 100) = 34.42$; $p < 0.05$) outperformed the control group. Therefore, the study concluded that CTCA is a potent approach for improving students' achievement in biology. It was recommended that the use of CTCA should be adopted by biology teachers in secondary schools to enhance learning.

KEYWORDS:
Culturo-techno-contextual approach, Biology, Culture, Achievement, Context

INTRODUCTION

Since the mid-nineteenth century, scholarly inquiry has been driven by the quest for more effective strategies to enhance students' academic performance. As a result of these endeavors, a multitude of teaching and learning approaches have been scrutinized in the literature. These include cooperative learning (Gillies, 2016), concept mapping (Schroeder et al., 2018), demonstrations (Ho et al., 2016), analogies, and metaphors (Choi and Kim, 2017), as well as constructivist methodologies (Chen and Bonner, 2017). Despite the implementation of some of these pedagogical strategies in classrooms, reports of suboptimal student achievement persist across various nations during the second decade of the twenty-first century (Ejiwale, 2013; Watkins & Mazur, 2013; Smith et al., 2014; d'Aguiar & Harrison, 2016; Hoeg & Bencze, 2017; Canning et al., 2018). This trend is disconcerting, given that these students represent the future workforce responsible for managing and advancing various societal domains. In response to the challenges faced by students across disciplines, scholars have recently advocated for the development and utilization of cultural models in education

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(Awaah et al., 2021; Brown et al. 2019; Okebukola, 2020). Culture has long been a focal point in educational research, particularly in addressing equity concerns for low-income, racial, and ethnic minority students (Carothers, 2018). Viewing classrooms as cultural spaces allows us to recognize the value of students' cultural perspectives as tools for learning (Seiler, 2013). The underlying premise of cultural teaching methods is that introducing new concepts to students through cultural and indigenous frameworks facilitates their comprehension of these novel ideas.

The Afrocentric teaching model, underpinned by a cultural orientation, places significant emphasis on digital technology within its methodology and delivery to meet the education needs of the African continent (Awaah et al. 2023). Okebukola (2020) asserts that students acquire a deeper understanding of topics when they are taught within their cultural context. This perspective led to the development of the culturo-techno-contextual approach (CTCA) (Okebukola, 2020). The Culturo-Techno-Contextual Approach (CTCA) emerges from over four decades of dedicated inquiry aimed at identifying a tool capable of dismantling barriers to meaningful science education. While various teaching methods—such as cooperative learning, concept mapping, discovery learning, demonstration, argumentation, mastery learning, and vee diagramming—have been explored to enhance science comprehension, their individual or combined efficacy has not consistently fostered meaningful science learning in Africa (Okebukola, 2020). Contextual factors play a pivotal role in this challenge (Oledejo et al., 2023).

CTCA represents a culturally and contextually relevant pedagogical approach designed to surmount traditional obstacles. These barriers include apprehension towards science due to its imported and complex language, inadequate teaching and learning facilities, the abstract nature of certain scientific concepts, and the perception that science is reserved for the intellectually gifted. CTCA draws upon three interconnected frameworks: (a) cultural context, immersing all learners; (b) technology mediation, increasingly integral to both teachers and students; and (c) locational context, unique to each school and influential in shaping science lessons through local case studies and examples. Since its official adoption as a teaching strategy in 2015, CTCA has undergone empirical scrutiny in Nigeria, Ghana, and Burundi. These studies have consistently reported positive impacts not only on students' learning outcomes but also on their attitudes towards learning (Adam et al., 2021; Oladejo et al., 2023; Onowugbeda et al., 2022; Awaah et al., 2024; Ademola et al., 2023). Recent research has further explored CTCA's effectiveness in promoting meaningful understanding of challenging STEM concepts. Noteworthy applications include in biology, the efficacy of CTCA has been tried out on various concepts including ecology, mutation, variation, genetics, and evolution (Awaah et al. 2023; Adebayo et al. 2022). In chemistry, the studies include (Ademola et al. 2023; Oladejo et al. 2024). CTCA has equally been tried out on ICT concepts such as logic gates, flowcharts, and algorithms (Gbeleyi et al. 2022) as well as in physics—refractive indices (Oladejo et al. 2023). Importantly, these investigations consistently demonstrate CTCA's positive impact on student learning outcomes, with no discernible gender differences.

Biology, as a natural science, focuses on the study of life and living organisms, encompassing aspects such as structure, function, growth, evolution, distribution, and taxonomic identification. It holds immense importance for all individuals, contributing to economic development and poverty reduction. Notably, Biology is considered a mandatory and foundational subject in secondary school education across Nigeria (Adam et al. 2023; Onowugbeda et al. 2022). Despite its significance, scientific reports highlight that students pursuing science disciplines encounter challenges with certain biology concepts, including

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genetics, tissue and support systems, ecology, variation, and evolution. These concepts are often perceived as complex facets of biology, leading to misconceptions and difficulties in comprehension (Abimbola, 2015; Auwalu et al., 2014; Adam et al., 2023). Consequently, many students tend to avoid questions related to these intricate concepts during their final examinations (Adelana et al., 2021).

Studies have attributed the complexity of certain biology concepts to their abstract nature (Etobro & Banjoko, 2017; Gusmalini & Wulandari, 2020; Kantahan et al., 2020), resulting in fewer students opting for biology disciplines compared to non-STEM fields, particularly among female students (Oladejo et al., 2021; Odufuwa et al., 2022). The challenges encountered in learning biology stem from various factors, including inadequate or nonexistent science laboratories, non-STEM educators handling biology classes, ineffective teaching methodologies, and a lack of modern instructional technologies tailored for biology education (Ajayi & Adelana, 2020; Odufuwa et al., 2022). To address this issue, several instructional strategies have been proposed. These include metaphorical instruction (Musa & Bello, 2022), logical prose combined with concept mapping (Alabi & Abimbola, 2022), gamification (Ajanaku et al., 2019), self-learning materials focused on genetics using multimedia (Ajayi & Adelana, 2020), learning cycles, and expository approaches (Adam et al. 2021). Additionally, annotated drawing (Danmole & Lameed, 2014) has been suggested. Other potential approaches involve design criteria methods (Knippels et al., 2005), utilization of multimedia resources (Starbek et al., 2010), incorporation of video games (Annetta et al., 2009), and the application of concept mapping and problem-solving strategies (Nudelma & Okechukwu, 2006). However, there has been limited attention given to the potential benefits of culturally relevant and contextually sensitive teaching approaches, such as the culture-techno-contextual approach, for effectively teaching and comprehending challenging biology concepts. Consequently, this study was guided by the following research questions:

- Is there any statistically significant difference in the achievement of students taught using CTCA and those taught with the conventional lecture method?
- What perception do students hold about learning biology using CTCA?

LITERATURE REVIEW

The Culturo-Techno-Contextual Approach (CTCA), introduced by Peter A. Okebukola in 2015, represents an Afrocentric teaching method that integrates culture, technology, and context to enhance meaningful learning experiences (Okebukola, 2020). Anchored in three philosophical foundations, the CTCA draws from Kwame Nkrumah's ethnophilosophy for culture, Martin Heidegger's technophilosophy for technology, and Michael Williams' contextualism for the contextual element (Okebukola, 2020). Ethnophilosophy involves the study of indigenous philosophical systems. It recognizes that a society's culture may yield philosophies that are not universally applicable but share parallels with other cultures. In this context, the CTCA emphasizes the importance of teaching African students using culturally relevant examples, recognizing that non-African methods may not always align with their specific living conditions (Awaah et al., 2021). In using the CTCA, he asserts that students are encouraged to enquire from their parents, guardians and elders in the community on cultural knowledge relative to concepts to be taught in class as prior knowledge before the subject is taught. By doing so, students gain valuable prior knowledge that enhances their understanding of concepts when formally taught in class. The teacher's role includes informing students in advance about the upcoming concept or topic, creating a bridge between cultural context and formal instruction.

The technological aspect of the CTCA framework draws upon Heideggerian philosophy, which involves utilising technology to transform nature into a resource for efficient utilisation (Awaah et al., 2021). In accordance with this philosophical perspective, CTCA advocates for the integration of contemporary technology, such as the Internet, personal computers, and mobile phones, into educational settings, facilitating enhanced information retrieval and accessibility of educational materials (Awaah et al., 2021a, b, c). Moreover, CTCA encourages educators, in collaboration with parents and educational institutions, to embrace technology to support students' comprehension of academic content. This necessitates the provision of technological resources, such as computers, laptops, Internet connectivity, and other supportive infrastructure, by parents and educational institutions to facilitate teaching and learning activities.

The contextual dimension, which serves as the foundation of CTCA, is rooted in Contextualism (Okebukola, 2020). Contextualism posits that our actions, communications, expressions, and learning experiences can only be fully comprehended within the context in which they occur (Okebukola, 2020). Consequently, CTCA advocates for the alignment of instructional materials with students' immediate environment to expedite their understanding of key concepts (Okebukola, 2020). This pedagogical approach establishes connections between learning activities and local communities, with the overarching objectives of enhancing student engagement, improving academic performance, fostering community impact, and nurturing appreciation for the surrounding world.

The theoretical underpinning of this study is grounded in Vygotsky's theory of social constructivism and instructional scaffolding, as well as Ausubel's theory of meaningful verbal learning and advance organizer (Vygotsky, 1962; Moses, 1992; Ausubel, 2012). Vygotsky posits that culture plays a pivotal role in the processing and construction of knowledge, asserting that learning occurs through social interactions within culturally defined contexts shaped by individuals' unique attributes, language, and experiences (Vygotsky, 1962; Moses, 1992). This emphasis on the cultural dimension of knowledge formation is central to the CTCA. Furthermore, Vygotsky's theory underscores the social nature of learning, highlighting the influential roles of parents, teachers, peers, culture, and society in the knowledge acquisition process (Vygotsky, 1962). According to Vygotsky, learning is intrinsically social, with significant contributions from familial and societal interactions in shaping a child's knowledge and behaviour aligned with societal norms (Vygotsky, 1962). This assertion lends support to the implementation of CTCA, which advocates for students to engage in social interactions to acquire indigenous cultural knowledge related to a given topic from their parents, guidance counsellors, or other knowledgeable individuals (Vygotsky, 1962). Such interactions with parents are instrumental in fostering the development of higher psychological functions in students, as they acquire pre-lesson knowledge that serves as an advance organizer, facilitating the integration of new information into their cognitive schema during subsequent lessons (Ausubel, 2012). Ausubel's theory of meaningful learning further elucidates this process, proposing the concept of an advance organizer as a pedagogical strategy to facilitate meaningful learning (Ausubel, 2012). An advance organizer serves to connect students' existing knowledge with new information, concepts, or materials, thereby promoting deeper understanding rather than rote memorisation (Ausubel, 2012). In essence, the integration of Vygotsky's social constructivist perspective and Ausubel's meaningful learning theory underscores the significance of social interaction and advance organisers in enhancing students' learning experiences within the CTCA framework.

RESEARCH METHODS

This study employed explanatory sequential design. The quantitative phase was quasi-experimental, and the qualitative phase was an in-depth interview. Two schools located in different parts of Lagos State education district V were purposefully selected to prevent students in each group from interacting with one another. Our choice of the study area was prompted by the record of high failure rate of students in the major science subjects including biology and their general lack of interest in science (Ademola, 2020). There were 61 students in the CTCA group (male = 28, female = 33) and 42 students in the lecture group (male = 19, female = 23). The CTCA group represents about 59.2% of the population, while the lecture group represents about 40.8% of the population. Students in senior secondary school II (the equivalent of 11th grade) were considered appropriate because, by the structure of the syllabus and general school calendar, at the time the study was conducted, they had not been taught the tissue and supporting system concepts treated in this study but had learnt the requisite concepts.

The quantitative data was collected using the Achievement test in Tissue and Supporting System (ATSS). The instrument (multiple choice) had 30 district items, each item had three distractors and one key. The items were evenly distributed across the cognitive process dimension (Anderson and Krathwohl, 2001) and all items carried equal score weight. It was validated by an expert in science education (biology option), English language and a biology teacher. A reliability coefficient of 0.76 was obtained for the instrument using the split-half procedure. Before treatment, the experimental and control groups were subjected to pretest, the treatment lasted four weeks and each week, there was a teaching contact of 60 minutes in each group. In week one, the students were taught tissue & supporting System concepts. Week two featured function and types of joints, in week three component of human skeleton was treated, while bones and cartilage were the focus of week four. The control group was taught using the conventional lecture method while the experimental group was taught following the five-step procedure for implementing CTCA at every lesson. The steps are as follows.

As a pre-lesson activity, the teacher instructed the students to (a) reflect on indigenous knowledge or cultural practices and beliefs associated with tissue and supporting system. The students were informed that these reflections were to be shared with their classmates when the topic was being taught. Additionally, (b) they were encouraged to utilise their mobile phones or other Internet-enabled devices to search the web for resources relevant to the lesson, representing the initial technology aspect of the teaching approach (first technology flavor of the approach).

At the commencement of the lesson, following the teacher's introduction, students were organised into heterogeneous mixed sex and mixed ability groups comprising 10 students each. They were tasked with exchanging individual reflections on (a) indigenous knowledge and cultural practices and beliefs related to the topic, and (b) summaries of information gathered from online resources. All such cultural and internet-based reflections were recorded and subsequently presented to the entire class by appointed group leaders. The teacher concluded the session by sharing their own indigenous knowledge and cultural practices pertaining to the topic.

Throughout the lesson, the teacher advanced by utilising practical examples sourced from the immediate vicinity of the school. These examples were tangible and observable by students, rendering the concepts more concrete and less abstract. This approach represents one facet of the contextual aspect of the teaching approach. Furthermore, the teacher injected elements of content-specific humour into the delivery of the lesson. As the lesson proceeded, emphasis was placed on the importance of the indigenous knowledge and cultural practices documented by the groups for facilitating a meaningful understanding of the concepts. Any misunderstandings arising from cultural beliefs were addressed and clarified by the teacher.

At the conclusion of each lesson, the teacher provides a concise summary of the material via WhatsApp to all students. These summaries are limited to 320 characters (equivalent to two pages in SMS format). Following the initial lesson, student group leaders assume the responsibility of composing and disseminating these summaries within the WhatsApp group. This practice exemplifies the integration of technology into the teaching approach.

Both the experimental and control groups underwent a pretest before the intervention and a posttest following the intervention, using the same Achievement Test in Tissue and Supporting System (ATTSS). It is noteworthy that the two regular teachers from both experimental and control group schools were retained throughout the study to prevent any potential teacher-related biases resulting from changes, which could influence the outcomes. Prior to the data collection phase, teachers were instructed to inform students that their performance in the test would not affect their academic scores for the school year, and no pass or fail grade would be assigned. This information aimed to alleviate the usual anxiety and stress associated with assessments and ensure the integrity of the data collected. Measures were taken to maintain a conducive classroom environment, free from distractions and monotony, during both the pretest and posttest administrations to enhance the reliability of the collected data.

Following the posttest, eight students from the experimental group were chosen for interviews regarding their perceptions of the CTC approach. The students' perceptions were assessed using the CTCA interview guide (SPCIG), which had been employed in a previous study conducted in a similar context. The interviews spanned two days and were conducted within the school premises under quiet conditions. To maximise student attentiveness, the interviews were scheduled during the morning hours (9:30 a.m.–10:30 a.m.), avoiding the students' break period (11:30 a.m.–12 noon). This scheduling aimed to prevent potential fatigue among students later in the day, ensuring their optimal concentration during the interview sessions. Each interview session lasted approximately 17 minutes.

RESULTS AND DISCUSSION

The two data sets (pretest and posttest scores) generated during data collection for the study were analysed using IBM SPSS version 23 software. The data for the first research question which sought the impact of CTCA in improving the achievement of secondary school students in tissue and supporting system concept was analysed using analysis of covariance (ANCOVA). Since the participants were not randomised, it was expedient to use ANCOVA to partial out the initial differences between the two groups.

Having confirmed that the two groups were not significantly different through Levene's test of homogeneity of variance ($F= 5.16$; $P> .05$) and the Shapiro -Wilk's test of normality was favourable for both groups; control group ($N=42$) = .30; $p> .05$ as well as for experimental group: ($N=61$) = .22; $p> .05$. The ANCOVA statistic applied on the pre-test and post-test scores of the two groups using the pretest scores as the covariate.

Table 1. Mean and Standard Deviation of Achievement Test Scores of the Two Groups

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Method	Number	Mean	SD
CTCA Group	61	10.53	3.65
Conventional Lecture Method Group	42	6.83	2.47

The results in Table 1 express the difference in the mean scores of the participants in both the and the experimental and control groups in favour of the experimental group (m= 10.53, Sd= 3.64). These results provide a necessary but insufficient answer to the research question one. At 95% confidence level and with the statistical tool having adjusted for any initial difference using the pretest achievement scores as shown in Table 2.

Table 2. ANCOVA Summary Table of Difference in the Achievement of the Two Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Pn²
Corrected model	365.784[a]	2	182.892	18.104	.000	.266
Intercept	560.694	1	560.694	55.502	.000	.357
Pre-Achievement	18.069	1	18.069	1.789	.184	.018
Groups	347.701	1	347.701	34.418	.000	.256
Error	1010.216	100	10.102			
Total	37968.00	103				
Corrected Total	1899.83	102				

a. R Squared = .266 (Adjusted R Squared = .251)

The table above revealed that there is a statistically significant difference in the achievement of students taught using the CTCA and conventional method [F(1,100)= 34.42; P< .05]. The R Squared shows that the independent variable accounted for 27% of the variation in the students' achievement in biology. The partial eta squared estimated indicated that the treatment accounted for 26% of the variance observed in the post-test on students' achievement in biology.

To address the second research question which sought students' perception about the use of CTCA to teach tissue and supporting system, the interview responses were analyzed thematically. This process involved manually transcribing the interviews in order to become familiar with the data. Next, initial codes were generated and applied to the data set. In the third phase, codes featuring similar contents were grouped together under the identified themes (Perception on CTCA, Impact of CTCA on concept understanding, Rating of CTC compared to conventional method) as shown in Table 3 below.

Table 3. Finding from the interview.

Theme	Summary of Finding
Perception on CTCA	All the participant (N=8) expressed their positive feedback on the method of instruction used in class. They found it effective, good, interesting, interactive, and

	able to make them understand the topic better. The method was also perceived to make studying easier and make the class lively. The students also appreciated how the method allowed them to know the capacity of their brains. The transcript is presented below; **"***The method of instruction I received today was effective" (*Student A, Male,15 years*)* "*It is a good method of teaching because it makes the students understand more about the topic that is being taught" (*Student B, Female, 14 years*)*
Impact of CTCA on concept understanding	All the participants (n=8) agreed that CTCA improved their understanding of the concept. They perceived CTCA as a teaching method that helps to break down barrier of difficult concept in biology like tissue and supporting system. They observed that CTCA allows for learners' alternative views to be exposed and discussed, particularly those relating to Indigenous, cultural beliefs and Contextual examples. This was reflected in the following statements: *"The impact it made on my ability is that it helps me to relate things from my environment and culture with the topic and when I see those things outside, I will be able to relate them with that topic. So, those who won't be able to understand the explanation will be able to understand it that way" (*Student A, Male,15 years*)*
Most preferred component of CTCA	Of the 8 students who took part in the interview, 5 (62.5%) chose technology as their favorite component of the teaching method, citing its ability to aid in researching and gaining knowledge about the topic. 2 students (25%) chose cultural, as they felt it related to their daily life and helped to connect them with their culture. Only 1 student (12.5%) chose contextual, noting that it provided an opportunity to share ideas and relate to the topic in a personal way. The transcript is presented below; "*Contextual and technology, Because, in the technology, we had to search about it on the internet while in the contextual, we came to share our ideas on what we found on the internet" (*Student A, Male,15 years*)*
Rating of CTCA compared to Conventional Lecture method	From the responses, CTCA method has a significantly higher level of satisfaction among students compared to the conventional lecture method. The CTCA method seems to have a high level of consistency in student satisfaction, with ratings ranging from 75% to 95%. The conventional lecture method, on the other hand, has a lower level of consistency in ratings, ranging from 5% to 25%. This was reflected in the transcript below; *"I will rate CTCA method 90% while Lecture method is 10% in terms of efficiency" (Student A, Male,15 years)* *"I will rate CTCA method 85% while for the conventional lecture method 15%"(Student B, Female, 14 years)*

Findings from the interview revealed that the students perceive learning biology using CTCA as highly effective and engaging. They find it increases their understanding, makes classes more interactive, and facilitates easier studying. CTCA relates scientific concepts to local environments and cultures, enhancing comprehension. Moreover, using phones to research topics further contributes to understanding. Compared to traditional lectures, CTCA receives significantly higher satisfaction ratings, indicating its effectiveness in promoting learning outcomes.

Discussion

The opening question in this study sought to find out if there would be a statistically significant difference in the achievement of students taught using CTCA and those taught with the conventional lecture method. It was revealed that a statistically significant difference existed between the groups in favour of the CTCA groups. This result is in accord with the findings of (Adam, et al. 2021; Akintoye et al. 2023; Onowugbeda et al. 2024). These studies tested the

potency of CTCA in biology against the traditional lecture method and found CTCA to promote meaningful learning of the concepts taught.
The alignment of the findings of the current study with those of previous studies underscores the significance and influence of culture, technology, and context on students' learning, particularly within the framework of the culturo-techno-contextual approach. It was hypothesised that the enhanced performance of the CTCA groups compared to the control group in understanding the concept of tissue and supporting systems can be primarily attributed to factors associated with the components of CTCA.

The cultural milieu in which learners are embedded played a pivotal role. As delineated in the treatment procedure, the "culturo" aspect of CTCA entailed instructing students to document indigenous knowledge and cultural customs relevant to the topics being covered. Through this exercise, students realised the value of their indigenous knowledge and cultural practices, which directly or indirectly elucidated the concept of tissue and supporting systems, supplementing the textbook examples typically limited to laboratory settings. Students in the CTCA groups arrived at class equipped with foundational indigenous knowledge and cultural practices, facilitating the assimilation of new topics. For these students, learning a new subject was akin to navigating a river, with indigenous knowledge or cultural practices serving as a buoyant raft aiding their progress. This conjecture finds support in the direct testimony of one of the interviewees, who expressed:
*"The impact it made on my ability is that it helps me to relate things from my environment and culture with the topic and when I see those things outside, I will be able to relate them with that topic. So, those who won't be able to understand the explanation will be able to understand it that way" (*Student A, Male,15 years*)*

Vygotsky's theory of social constructivism provides a robust foundation for the enhanced performance observed in the CTCA groups. Prior to each lesson, students were instructed to engage with their parents or another knowledgeable adult regarding cultural practices or local knowledge relevant to the content, as well as to watch related videos on YouTube, representing technology-mediated learning. Upon arrival in the classroom, students shared their findings with each other. Through these interactions with parents and YouTube videos, serving as more knowledgeable others (MKOs), students acquired knowledge. Additionally, they benefited from peer interactions and scaffolding, gradually transitioning from their current level of ability to a higher level within their zone of proximal development (ZPD), as conceptualised by Vygotsky (1962). The pre-lesson activities assigned to CTCA students undoubtedly contributed to their learning. Drawing on Ausubel's notion, these activities functioned as advance organisers, guiding students towards their ZPD, which is believed to facilitate learning. This conjecture finds support in the direct testimony of one of the interviewees, who stated that:
"*Going online and asking my parents about every lesson before the class aided my understanding of the topics because it usually gives me a preview of what the topics we are about learn, it makes me understand the topics better. The part of the method that I find most interesting is the indigenous part" (*Student B, Female, 14 years*)*

Another aspect of the CTCA framework, which logically elucidates the improved performance of students in the CTCA groups, was the incorporation of contextual examples in the CTCA lessons. As posited by Okebukola et al. (2020), the locational context represents the distinctive identity of each school, significantly influencing the selection of examples and local case studies for science lessons. Pobiner et al. (2019) contended that utilising pertinent human examples enables even upper primary school students to comprehend fundamental evolutionary concepts in biology. Furthermore, they argue that employing relevant examples fosters student engagement in the classroom and fosters an interactive learning environment. The contextual aspect of CTCA, emphasising the utilisation of practical examples within students' learning environment, serves to reinforce knowledge and facilitate meaningful learning of intricate science concepts. The students exhibited enthusiasm upon realising this, as evidenced by their responses during the interviews. Hence, it is reasonable to infer that the use of examples that are distant or unrelated to students' context renders science concepts more abstract and challenging to grasp. Conversely, contextually relevant examples support learning and contribute to the sound development of a mental framework of ideas.

The second research question sought students’ perception about CTCA as an approach to learning biology. The findings unveiled a positive perception among students towards learning biology with CTCA. The interview schedule was designed to elicit the interviewees' opinions on CTCA, its impact on comprehension of concepts, and their preferred aspects of the approach. All interviewees expressed favourable impressions of the instructional method employed in their classes, deeming it effective, engaging, intriguing, interactive, and conducive to deeper understanding of the subject matter. Furthermore, they perceived this method as facilitating easier learning and injecting vibrancy into the classroom environment. A majority of participants (62.5%) identified technology as their preferred component of the teaching approach, highlighting its role in facilitating research and knowledge acquisition. Meanwhile, 25% of students favoured the cultural component, citing its relevance to their daily lives and its capacity to foster a connection with their cultural heritage. Conversely, 12.5% of respondents selected the contextual aspect, emphasising its provision of opportunities for idea-sharing and personal engagement with the topic. These findings resonate with prior studies (Oladejo et al., 2023; Adam et al., 2021; Awaah et al., 2023), which similarly reported students' positive attitudes towards the use of CTCA for instructional purposes. Additionally, seven interviewees acknowledged the engaging and instructive nature of cultural and online video elements in their learning experiences. For some students, this exposure represented their first tangible encounter with the relevance of their cultural practices to academic learning, challenging the notion of science as entirely abstract. Continued exposure to such instructional methods may reshape students' perceptions of scientists, potentially diversifying traditional stereotypes and enhancing their self-concept as aspiring scientists, thereby contributing to improved scientific literacy within our society. The increased inclination towards online lesson videos was attributed to the growing dependence on internet resources among both teachers and students for problem-solving in everyday scenarios.

CONCLUSION

In teaching and learning, indigenous knowledge and cultural references are present in all communities worldwide. These can be utilised to facilitate a comprehensive comprehension of concepts in STEM subjects, as demonstrated in this study. This underscores the universal applicability of the culture-techno-conceptual approach and, consequently, the broader significance of our findings. It is noteworthy that culturally relevant teaching approaches in science have been explored in numerous global communities long before the inception of CTCA (Ladson-Billings, 2000). Therefore, CTCA can be regarded as a novel iteration of culturally relevant teaching methodologies that can be employed to teach and learn any STEM subject across different geographical regions.

Given that the focus of this study was to compare the performance of the focus of this study was to compare the achievement of students taught with CTCA and conventional lecture method. The results presented show that CTCA is effective in improving students' understanding of biology concepts as compared to the conventional lecture method. Therefore, our findings have extended the validity of CTCA (as established by previous studies) as an approach that can be used to promote meaningful learning of STEM subjects among secondary school students.

Our findings yield several recommendations for educational reforms. Firstly, there is a necessity for a trial implementation of the CTCA in Nigerian secondary schools as a pedagogical method for teaching biology, with the aim of further scrutinising its practical effectiveness. Secondly, educators should promote the technological aspect of CTCA by encouraging students to utilise mobile phones to enhance their learning experiences. Thirdly, the Ministry of Education and professional organisations should arrange workshops, seminars, and conferences for biology teachers to familiarise them with the application of CTCA, fostering its continuous implementation and assessing its effectiveness. Lastly, the science curriculum should explicitly acknowledge the cultural context of society, recognising its backdrop and the needs it serves.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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