Journal of Educational Sciences
Journal homepage: https://jes.ejournal.unri.ac.id/index.php/JES

P-ISSN
2581-1657
E-ISSN
2581-2203

Investigating the Impact of Culturo-Techno-Contextual Approach on Enhancing Critical Thinking in Science: Gender Dynamics and Learning Efficacy

Hakeem O. Akintoye[1], Olajumoke S. Oludipe[2], Adekunle I. Oladejo[1], Kaothar M. Abdulkareem[2], Isaac Bankole[2], Soladoye Lameed[2], Franklin U. Onowugbeda[1], Obabi-Benson A. Benjamin[2], Umar A. Adam[2*]

[1]*Africa Centre of Excellence for Innovative and Transformative STEM Education;*
[2]*Department of Science and Technology Education, Lagos State University, Ojo, Nigeria, Lagos State University, Ojo, Nigeria.*

ARTICLE INFO

Article history:

Received: 27 August 2024
Revised: 12 Sept 2024
Accepted: 02 Oct 2024
Published online: 26 Oct 2024

Keywords:

Gender;
Culturo-Techno-Contextual Approach;
Learning Efficacy;
Science

A B S T R A C T

This study aimed to evaluate the effectiveness of Culturo-Techno-Contextual Approach (CTCA) in enhancing students' critical thinking abilities in science with focus on hydrocarbon and to examine the gender impact on these abilities within the experimental group. A total of 127 science students for both the control (54 students) and the experimental group (73 students) in senior secondary year two (SS2) and 47 females and 26 males in the experimental group participated in the study. The research design was quasi-experimental (a pre-test post-test non-equivalent group) design. The instrument used to gather data was the hydrocarbon critical thinking test (HCTT). The results showed no significant difference in post-test mean scores between male and female students, although the CTCA treatment significantly improved students' overall critical thinking. No interaction effect between treatment and gender was observed. These findings highlight CTCA's potential to alleviate learning challenges in science and bridge the critical thinking gap between male and female students.

1. Introduction

The rapid advancement of science and technology in the 21st century necessitates a big educational shift. Education in the 21st century is characterized by the integration of knowledge, skills, attitudes, and mastery of information and communication technology (Rushiana et al., 2023). Within this, four essential skills stand out: critical thinking and problem-solving, creativity and innovation, communication, and collaboration. Therefore, critical thinking is identified as the most dominant and necessary skill for addressing the demands of modern

[*] Corresponding author.
E-mail: adamumar246@gmail.com
Doi: https://doi.org/10.31258/jes.8.4.p.656-670

scientific inquiry (Frima et al., 2020; Fuad et al., 2017). It is not merely an academic exercise but a high-level cognitive skill crucial for solving complex problems that require in-depth analysis and nuanced understanding (Wardani et al., 2019).

Students engaged in learning science must go beyond the rote memorization of science content. They need to develop an understanding of concepts and the ability to apply these concepts to solve real-world problems. Furthermore, understanding science concepts and their applications is vital for problem-solving in everyday life, underscoring the necessity of critical thinking skills in this field (Fernanda et al., 2019). The efforts of the teachers to promote the critical thinking skills of the students in science learning have not been fully carried out (Hadisaputra et al., 2020). This highlights the importance of critical thinking skills training and how it is currently not in line with the learning conditions in schools.

Student Cognitive Competence in Science

Several cognitive and affective elements can influence students' learning outcome in science. Instructional techniques, motivation, and cognitive skills are some of the aspects that affect students' cognitive competency (Dori & Avargil, 2015). Students who possess cognitive abilities, such as self-regulation and reflection, can organize, track, and assess how well they comprehend and approach the study of different area of science comprising of Biology, Physics and Chemistry. Furthermore, there are ample evidence have shown that various techniques help students learn beyond mere knowledge level beyond memorization (Cook et al., 2013).

Trends in recent studies have shown that knowledge retention does not only enhance students' cognitive competence but it also helps the students to retain knowledge beyond the immediate time of the lesson (Adebayo et al 2022, Oladejo et al, 2022, Akinola 2019). Students whose motivation are driven are more likely to connect with the content thoroughly, work through challenging issues, and show a sincere interest in the subject. According to Magwilang (2016), students' intrinsic motivation can be greatly increased by context-based learning, which links chemical principles to practical applications. Similar findings were reported by Vaino et al. (2012), demonstrating that context-based learning enhanced motivation and had a favourable impact on students' attitudes towards science. Students are more likely to obtain an understanding of these science subjects when they believe it is relevant to and useful to their daily lives. This positive attitude is crucial as it reduces anxiety and resistance to learning, making students more open to engaging with complex and abstract concepts.

Gender Differences in Science

Numerous factors, such as educational methods, resource availability, and societal expectations, might impact gender disparities in academic achievement. Male students have been seen to outperform female students, a chronic problem that Ezeudu and Theresa (2013) explained. This result is consistent with wider worries regarding the low number of women in STEM professions, which are frequently linked to societal prejudices and gender stereotypes discouraging women from pursuing jobs in science and technology. Gender difference has been a long-coming issue in students' performance in Science and is largely due to the non-girl-child friendly methods of teaching adopted by the teachers over the years (Nzewi 2020, Oludipe 2013).

The Stereotype Threat Theory (STT) investigated on gender about gender variations teaching and learing, males were reported to have lower test anxiety and stronger self-efficacy than women, but under stereotype threat situations, did not find any differences between the gender (Sunny et al., 2016) Similarly in Oladejo et al. (2021), Oladejo et al. (2022), Ademola et al. (2023b), Oladejo et al., (2023) and Oladejo et al., (2024) Thus, male students did not do much better than the females in their performance in science classes. On the other hand, Eugene and Ezeh (2016) study implies that gender is not a consistent predictor of achievement. Additional insights, showed that female students had more difficulty than male students with perceived difficult chemistry concepts (Oladejo et al., 2023a). Gender has a complex connection when it relates to science education. While there are gender variations in achievement, stereotype threat does not always have the same impact on them or all areas.

Culturally Relevant Pedagogy and Culturo-Techno-Contextual Approach (CTCA)

Ladson-Billings (1995) developed the concept of culturally relevant pedagogy (CRP), which places a strong emphasis on developing critical consciousness, cultural competency, and high expectations for every student. Building on this basis, The Culturo-Techno-Contextual Approach (CTCA), invented by Peter A. Okebukola and introduced in 2015 is one noteworthy advancement. The three legs of this approach's foundation are context, technology, and culture. It synthesizes the cultural environment, technology-mediated communication on which teachers and students are increasingly reliant, and locational context, which is the unique identity of each school and necessary for citing local examples that learners can easily comprehend (Adam et al., 2021; Okebukola, 2020).

This supports the focus Ladson-Billings places on critical consciousness and cultural competence while also acknowledging the cultural backgrounds of the students. Also, The social constructivism theory of Vygotsky provides a strong basis for comprehending the group ability for CTCA instruction because students interact with one another to gain comprehension of cultural practices that is pertinent to the subject matter. Through the process of creating their understanding, they can go up to an expanded zone of proximal development (ZPD), progressively moving beyond their zone of autonomous competence. In addition, the integration of technology within the CTCA framework improves the educational process by giving students access to digital tools and resources that support immersive and interactive learning. The locational context, another key component of CTCA, ensures that teaching methods and materials are tailored to the specific needs and circumstances of the learners. Show in Figure 1.

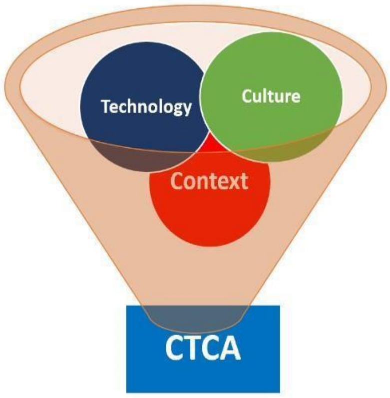

Figure1. CTCA framework (Okebukola, 2020)

CTCA is a learner-centered approach as opposed to the conventional lecture method. Its foundation is rooted in the idea that meaningful learning occurs when there is a link between existing knowledge and new knowledge. Okebukola (2019) opined that the CTCA provides a functional and supportive learning environment where the learner receives encouragement, commendation, and positive feedback after each assignment. Indigenous knowledge (IK) is noteworthy in the context of the cultural context in CTCA. All lessons are connected to students' indigenous knowledge systems and cultural practices when CTCA is implemented in science classrooms. Incorporating indigenous knowledge and cultural practices into academic curricula across multiple disciplines may have a positive impact on students' interest in science, ultimately supporting and enhancing science and preserving the indigenous knowledge of their culture (Adam et al. 2023 Kasanda et al., 2005; Perin, 2011). Show in Figure 2.

Figure 2. Relationship between culture and Indigenous knowledge (Okebukola, 2020*)*

The second component of the CTCA is the use of technology in and out of the classroom. The role of technology in promoting or inhibiting meaningful learning in and outside the four walls of the classroom,Today’s learners often use social media and web resources for their learning activities (Adwan et al., 2013). CTCA takes advantage of students’ frequent use of these sources to enhance teaching and learning activities. The third component of the CTCA, which is the use of contextually relevant examples in the classroom to exemplify and simplify difficult concepts in science, has also been found very effective in enhancing students' learning outcome in science and technology (Saanu, 2015; Okebukola et al., 2016). Using the locational context of the learners or the school environment helps to concrete learning and removes the abstract nature of science.

Various studies have focused on the usage, impetus, and benefits of culturally relevant teaching on secondary school students learning outcome (Ademola et al. 2023; Oladejo et al., 2024; Onowugbeda et al. 2022; Ladson-Billings 2023). Specific efforts have been geared towards increasing the academic achievement of students (Abah et al., 2015; Farinde-Wu et al., 2017; Gbamanja 2014; Mawere 2015). According to Gbamanja (2014), using local or community knowledge in science instruction, improves secondary school science achievement and attracts more students to science learning. Mawere (2015) claims that by offering a structure for problem-solving techniques and scaffolding learning, integrating students' cultural experiences and activities into the teaching and learning process promotes the development and preservation of local culture and values. According to Adam et al. (2024), this type of pedagogy is proposed to support an environment of teaching and learning that successfully connects science with daily life.

The study is guided by the following research questions:
1. Will there be a statistical difference in the critical thinking ability of students taught using CTCA and those taught using the lecture method?
2. Is there a statistically significant difference in the critical thinking ability of male and female students taught using CTCA?

2. Methodology

The researcher employed a pre-test and post-test quasi-experimental research design. To achieve this, two public schools each were purposively sampled from the educational district V in Lagos State. The schools were randomly sampled to ensure representativeness and diversity in the study population. The experimental group consisted of 1 selected school where the CTCA was implemented, while the control group encompassed 1 school where the conventional lecture method was applied. Senior secondary school year two students participated in the study. Each school that participated had a chemistry teacher, a school laboratory, and a record of teaching the students. The major criterion for eligibility in the study was students' access to internet-enabled devices, particularly after school hours. The schools were considerably distanced from one another to avoid undue interaction that may confound the outcome of the study among the participants.

The hydrocarbon critical thinking test, which was a multiple-choice items instrument was developed to collect the data for this study. The instrument was developed using past questions from the West African Senior School Certificate Examination (2014–2022). The instrument contained 30 discrete items with four options lettered A–D, the options to each question had one key and three distractors. The instrument was validated by three chemistry teachers with over 10 years of experience. The function of the chemistry teachers was to scrutinize each district item and the corresponding options to ensure that they were not beyond the scope of the content to be taught to the students and were in line with the behavioural objectives outlined in the lesson plans. All comments and observations were resolved accordingly before the administration of the instruments to the students. At the end of the treatment period, a posttest was conducted for each of the groups using the Hydrocarbon Cognitive Thinking test that was used to collect the pretest data on measures of students' critical thinking ability**.** The time allocation for test completion was the same for the two groups. The quantitative data collected was analyzed using a one-way analysis of covariance statistics in IBM-SPSS version 23, given that there was one dependent variable (Critical thinking) in the study and the students were not randomly assigned to groups. The pretest scores on critical thinking were used as the covariate to partially exclude the effects of any form of initial difference in the group on the outcome of the study.

Treatment Procedure

The Culturo-Techno-Contextual Approach is a method of teaching that gives students the tools they need to understand science in a digital context not as an abstract idea, but as a body of information that is relevant to their everyday lives and exists in their surroundings and culture. During the treatment phase of the study, the experimental group were taught using Culturo-Techno-Contextual Approach five steps of delivery as shown. Show in Figure 3.

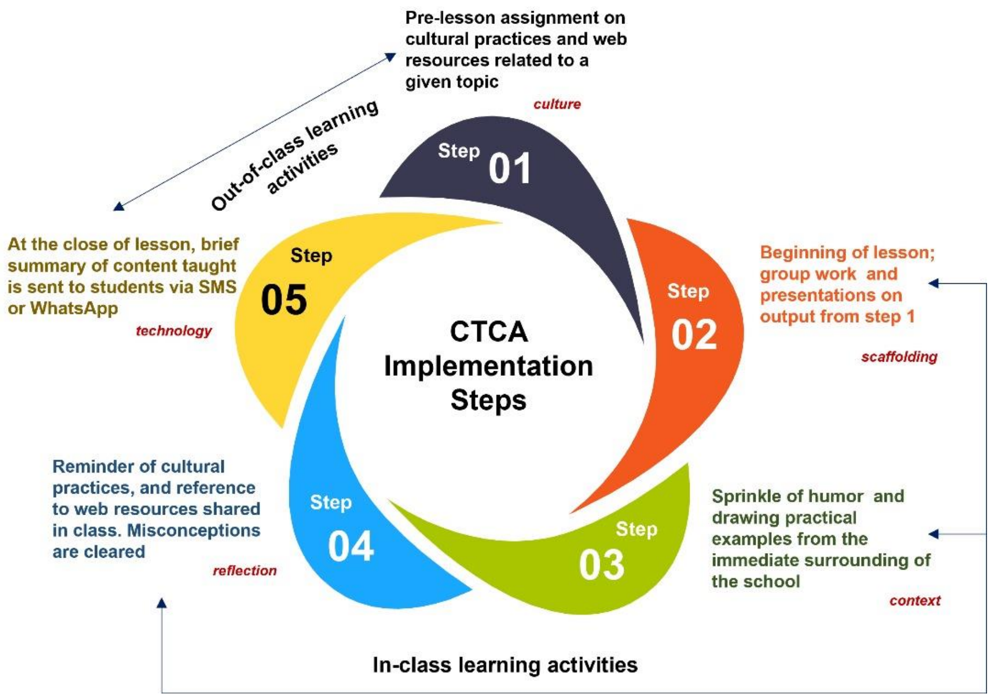

Figure 3. CTCA Implementation Steps (Oladejo et al., 2023)

The implementation of Culturo-Techno-Contextual Approach began outside the classroom when the teacher informed the students ahead of the lesson time of the topic to be learned in class where students were tasked to use their mobile phones to search web resources reflecting on or making inquiry of their parents, caregivers, siblings, or any more knowledgeable other on Indigenous knowledge or cultural practices/beliefs associated with the topic or concept. Moving on, The lesson commenced in the class with the introduction of the topic by the teacher and the teacher proceeded to group the students to share individual findings generated from outside the classroom activities. As the lesson progressed, the teacher draws up examples that are within the immediate environment of the students/school to exemplify and simplify the concepts in the topic and does so with a sprinkle of content-specific humor to make the learning fun and activity-oriented. Furthermore, the teacher reminded the students of the relevance of the Indigenous knowledge or cultural practices documented by the groups for meaningful understanding of the concepts. Possible misconceptions that are associated with cultural beliefs are clarified by the teacher. At this stage, students are allowed to ask questions, if any, and the teacher may also wish to evaluate the students. 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. With a maximum of 320 characters. The summary of the first lesson was sent by the teacher to all students, and after the first lesson, student group leaders are accorded the responsibility of sending such messages after each class.

3. Results and Discussion

The data collected for this study were analyzed using one Ancova. The results obtained from the parametric assumption test carried out on the data collected showed in Table 1 that the data satisfied the assumption of homogeneity of variance among the groups on the dependent variable (Critical Thinking-F = 0.850; p 0.05).

Table 1. Output for the test of homogeneity of variance

		Levene Statistic	df1	df2	Sig.
Critical Thinking Posttest	Based on Mean	.850	1	125	.358

The result obtained in Table 2 showed that students in the experimental group had a higher mean score (8.93) than their counterparts in the control group (8.17). Thus, the obtained result was subjected to inferential testing as shown in Table 1 to ascertain whether the observed difference is statistically significant or not due to error variance.

Table 2. Mean and Standard Deviation for the Control and Experimental Groups

Method	**Mean**	**Std. Deviation**	**N**
Use of CTCA	8.93	2.51	73
Lecture method	8.17	2.49	54
Total	8.61	2.52	127

The result in Table 3 shows that penultimate students of both groups (CTCA and Lecture method) were significantly different from one another in terms of critical thinking ability (p = 0.022). However, after treatment, the result showed that the experimental group significantly outperformed (F(1, 124) = 5.361; p 0.05) the control group.

Table 3. ANCOVA Summary Table of Differences in Critical Thinking Ability of Control and Experimental Groups

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Critical Thinking Pretest	33.233	1	33.233	5.517	.020
Method	32.292	1	32.292	5.361	.022
Error	746.924	124	6.024		

Tests of Between-Subjects Effects
Dependent Variable: Critical thinking Ability

a. R Squared = .064 (Adjusted R Squared = .049)

The partial eta squared estimate indicated that the treatment accounted for about 4.9% of the variance observed in the post-test on students' critical thinking ability in subject like chemistry. Based on this result, the hypothesis that there will be no statistically significant difference in the critical thinking ability of students taught Hydrocarbon using CTCA and those taught using the lecture method is therefore rejected. On the second research question, the result of the descriptive analysis revealed in Table 4 that the females had a slightly higher mean score (9.02) than the male students (8.77).

Table 4. Mean and Standard Deviation in Critical Thinking Ability of Male and Female Students in The Experimental Group

Gender	**Mean**	**Std. Deviation**	**N**
Female	9.0213	2.63331	47
Male	8.7692	2.30318	26
Total	8.9315	2.50737	73

Therefore, the male and the female students in the experimental group were significantly different in measuring their critical thinking ability.

Table 5. ANCOVA Summary Table of Differences in The Experimental Group Critical Thinking Ability Among Male and Female Students

Dependent Variable: Critical Thinking ability

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Critical Thinking Pretest	14.888	1	14.888	2.386	.127
Gender	3.049	1	3.049	.489	.487
Error	436.706	70	6.239		

However, after treatment, the inferential statistic (one-way analysis of covariance) applied to the obtained data in Table 5 shows that the observed difference in the mean scores of the CTCA female and male students did no longer attain statistical significance [F (1,70) = 0.49; p .05].

Discussion of Result

The opening question in this study aimed to determine if there would be a statistically significant difference in the Critical Thinking Ability (CTA) of students taught using the traditional lecture method compared to those taught using the Culturo-Techno-Contextual Approach (CTCA). Upon measuring CTA, we found a statistically significant difference among the groups. Specifically, each of the experimental groups (i.e., the CTCA groups) outperformed the group taught using the lecture method. This result aligns with the findings of Onowugbeda et al. (2023); Akintoye et al. (2023); who demonstrated that using culturally relevant approaches to science instruction and practice significantly increased student progress, critical thinking ability, skill development, and interest. Ajayi et al. (2017) further supported this by showing that culturally relevant teaching methods heighten students' sense of belonging and identity. According to Sumarni and Kadarwati (2020), creating an inclusive learning environment where students feel valued and understood is essential for developing a sense of belonging. It also improves scientific literacy (Sudarmin et al., 2018).

Gbamanja (2014) emphasized the importance of incorporating local or community knowledge in science instruction, particularly in Africa. This approach not only improves secondary school science achievement but also attracts more students to science learning. Further studies corroborate these findings, highlighting the positive impact of culturally relevant teaching on secondary school students' learning performance. For instance, Ademola et al. (2023) and Oladejo et al. (2024) found that students taught using culturally relevant methods showed significant improvements in their academic performance and critical thinking skills compared to those taught using traditional methods. Ladson-Billings (2023) also documented the wide-ranging benefits of culturally relevant pedagogy in promoting student engagement and achievement across diverse educational settings.

All of these point to the possibility that integrating cultural context and responsive teaching strategies can improve students' critical thinking skills and engagement in general. Students are more likely to engage deeply with the material, think critically about it, and apply their knowledge in novel ways when they see the relevance of what they are learning in the context of their own lives and cultures. Science becomes more relatable and meaningful to students as a result, which improves student engagement and learning outcomes. Students find Science Concepts more approachable and interesting when culturally relevant teaching approaches are used because they can immediately relate what they are learning to their own lives and cultures. Therefore, culturally relevant teaching approaches, such as CTCA, enhance students' critical thinking abilities and overall engagement. Increasing the cultural relevance and contextual relevance of learning.

The second research question focused on finding if the female students in the CTCA group would outperform their male counterparts (or vice versa) using their critical thinking ability, such that the difference in their ability would attain statistical significance or not. Our findings revealed that no statistically significant difference was found between the male and female students. Specifically, male students did not perform significantly better than female students in both the achievement test and the anxiety-level test. This suggests that CTCA provided an equitable learning environment where both genders could develop their critical thinking abilities effectively. These studies by Sunny et al. (2016), Oladejo et al. (2021), Oladejo et al. (2022), Ademola et al. (2023), Oladejo et al. (2023b), and Oladejo et al. (2024) align with our findings, reporting no significant gender differences in academic performance. In these studies, male and female students performed similarly on various metrics, suggesting that gender does not play a decisive role in determining students' academic success within similar instructional design.

The lack of significant difference might indicate that stereotype threats or societal expectations regarding gender and performance do not directly impact student outcomes in these contexts. In contrast; Eugene and Ezeh (2016) found that female students outperformed male students, highlighting a significant gender difference in favour of females. This discrepancy might be due to differing instructional methods, cultural contexts, or sample characteristics that influenced the outcomes differently Oladejo et al. (2023a) discovered that female students faced more difficulty with chemistry concepts than male students. This finding contrasts with the current study's results, suggesting that under different educational approaches or contextual variables, gender disparities might emerge.

The absence of a significant gender difference in the CTCA group suggests that the Culturo-Techno-Contextual Approach creates an inclusive learning environment that supports both male and female students equally as it may help mitigate gender-based disparities in academic ability by providing culturally relevant and contextually rich learning experiences that resonate with all students, regardless of gender. Rather than gender alone, other individual differences such as prior knowledge, learning styles, and personal interests may play a more significant role in determining a student's Critical Thinking Ability when taught using CTCA.

4. Conclusion

The purpose of this study was to investigate the potency of the Culturo-Techno-Contextual Approach on students' critical thinking ability in traditionally perceived difficult concepts in science and the effect of gender on the experimental group's critical thinking ability. We found that the post-test mean scores of CTCA female and male students did not attain statistical significance. The test of main effects conducted also showed that there was a significant main effect due to treatment on the critical thinking ability of the students. No statistically significant interaction effect due to treatment and gender was recorded. These results confirm the potency of the use of CTCA in instructional delivery to ease students' learning difficulties in science concept like hydrocarbon in chemistry. Most importantly, the evidence that the use of CTCA in science classroom to bridge the long-existing gap in the critical thinking ability of male students over females was established by this study. This position was equally supported by the findings of similar studies conducted within and outside Nigeria. While the intention of this study is not to generalise beyond the population as a result of limitations due to sample size, we consider it beneficial to offer the following recommendations: Curriculum Developers should Integrate the CTCA into the science curriculum to improve students' understanding and critical thinking in difficult concepts. This approach has been shown to significantly enhance students' learning experiences and outcomes. Policymakers should develop policies and initiatives that ensure equal opportunities and support for both male and female students in science education. The study’s findings indicate that CTCA helps bridge the critical thinking ability gap between genders, promoting gender equity.

References

Abah, J., P. Mashebe, and D. D. Denuga. (2015). “Prospect of Integrating African Indigenous

Adam, U. A., Okebukola, P. A., & Oladejo, A. I. (2021). Exploring the Efficacy of the Culturo-Techno-Contextual Approach (CTCA) in Improving Academic Achievement of Secondary School Students in Genetics. Proceedings of the Faculty of Education Annual Conference, Lagos, Nigeria.

Adam, U. A., Lameed, S. N., Tonade, O., Onowugbeda, F. U., Ayodeji, B., Michael, I. A., & Muraina, I. O. (2023). A New Piece of the Puzzle: Deploying Technologically-Enhanced Jigsaw Method to Solve the Puzzle of Meaningful Learning in Biology. *ASEANA Science and Education Journal, 3(1),* 8-17

Adam, U. A., Onowugbeda, F. U., Islami, N., & Ogolo, K. G. (2024). Testing the potency of ethnoscience instruction on biology students’ critical thinking ability. *The Journal of Educational Research*, 1-10.https://doi.org/10.1080/00220671.2024.2373464

Adebayo, I., Oladejo, A. I., & Okebukola, P. A. (2022). Examining the Relative Effectiveness of CTCA in Improving Secondary School Students’ Achievement in Genetics. In Proceedings of the NARST 95th Annual International Conference: Unity and Inclusion for Global Scientific Literacy: Invite as a Community. Unite as a Community, Vancouver, BC, Canada (pp. 27-30).

Adedokun, A. O. (2019). Effects of instruction and location of topic sentence on academic achievement of rural and urban students in reading comprehension. *International Journal of Arts And Technology Education (IJATE) Volume 11*, No. 1

Ademola, I. A., A. I. Oladejo, O. A. Gbeleyi, F. U. Onowugbeda, O. L. Owolabi, P. A. Okebukola, and S. I. Uhuegbu (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

Adwan, A., A. Al-Adwan, and J. Smedley. (2013). “Exploring Student’s Acceptance of e-learning Using the Technology Acceptance Model in Jordanian Universities.” *International Journal of Education and Development Using ICT 9 (2).*

Agbanimu, D. O., Okebukola, P. A., Oladejo, A. I., Onowugbeda, F. U., Peter, E. O., Awaah, F., & Allename, F. A. (2022). Flowchart and Algorithm as Difficult Concepts in Computer Studies: Can CTCA Come to the Rescue? [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.

Akintola, A. (2019). Impact of culturo-techno-contextual (CTC) approach on students’ achievement on perceived difficult topics in biology. Unpublished research project report for the degree of Bachelor of Science Education.

Akintoye, H., Adam, U. A., Lameed, S. N., Bankole, I. S., & Ayodeji, B. (2023). A Case for Culturo-Techno-Contextual Approach for Enhanced Academic Achievement in STEM Education. *Journal of Educational Sciences, 7(4),* 530-544.

Bæck, U. D. K. (2016). Rural location and academic success—Remarks on research, contextualization and methodology. *Scandinavian Journal of Educational Research, 60(4),* 435-448.

Cook, E., Kennedy, E., & McGuire, S. Y. (2013). Effect of teaching metacognitive learning strategies on performance in general chemistry courses. *Journal of Chemical Education, 90(8),* 961–967. https://doi.org/10.1021/ed300686h

Dori, Y. J., & Avargil, S. (2015). *Promoting metacognitive skills in the context of chemistry education.* In Sense Publishers eBooks (pp. 119–141). https://doi.org/10.1007/978-94-6300-175-5_7

Eugene, U., & Ezeh, D. (2016). Influence of Gender and Location on Students’ Achievement in Chemical Bonding. *Mediterranean Journal of Social sciences, 7,* 309. https://doi.org/10.5901/MJSS.2016.V7N3P309

Ezeudu, F., & Theresa, N. (2013). Effect of Gender and Location on Students' Achievement in Chemistry in Secondary Schools in Nsukka Local Government Area of Enugu State, Nigeria. *Research on humanities and social sciences, 3,* 50-55.

Farinde-Wu, A., C. P. Glover, and N. N. Williams. (2017). “It’s Not Hard Work; It’s Heart Work: Strategies of Effective, Award-Winning Culturally Responsive Teachers.” *The Urban Review 49 (2):* 279–299. https://doi.org/10.1007/s11256-017-0401-5 .

Fernanda, A., Haryani, S., Tri Prasetya, A., & Hilmi, M. (2019). Analisis Kemampuan Berpikir Kritis Siswa Kelas XI pada Materi Larutan Penyangga dengan Model Pembelajaran Predict Observe Explain. *Jurnal Inovasi Pendidikan Kimia, 13(1),* 2326–2336. https://doi.org/10.15294/jipk.v13i1.16183

Frima, F. K., Gun Gumilar, G., & Titin Supriyanti, F. (2020). Pengaruh Metode Discovery-Inquiry terhadap Profil Keterampilan Berpikir Kritis Siswa pada Pembelajaran Topik Kelarutan. *Journal Pendidikan Sains (JPS), 8(1),* 41–49. https://doi.org/10.26714/jps.8.1.2020.41-49

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving junior high schools' critical thinking skills based on testing three different models of learning. *International Journal of Instruction, 10(01),* 101–116. https://doi.org/10.12973/iji.2017.1017a

Gbamanja, S. P. T. (2014). "Nexus Between Science and Culture: A Panoramic View from Sierra Leone." *Journal of African Culture and International Understanding 3 (7):* 16–24.

González, A., & Paoloni, P. (2015). Perceived autonomy-support, expectancy, value, metacognitive strategies and performance in chemistry: a structural equation model in undergraduates. *Chemistry Education. Research and Practice, 16(3),* 640–653. https://doi.org/10.1039/c5rp00058k

Hadisaputra, S., Ihsan, M. S., Gunawan, N., & Ramdani, A. (2020). The development of chemistry learning devices based blended learning model to promote students' critical thinking skills. *Journal of Physics. Conference Series, 1521(4),* 042083. https://doi.org/10.1088/1742-6596/1521/4/042083

Kasanda, C., Lubben, F., Gaoseb, N., Kandjeo-Marenga, U., Kapenda, H., & Campbell, B. (2005). The role of everyday contexts in learner-centered teaching: The practice in Namibian secondary schools. *International Journal of Science Education, 27(15),* 1805-1823.

Knowledge Systems into the Teaching of Sciences in Africa." *American Journal of Educational Research 3 (6):* 668–673.

Ladson-Billings, G. (1995). "But That's Just Good Teaching! The Case for Culturally Relevant Pedagogy." *Theory into Practice 34 (3):* 159–165. https://doi.org/10.1080/00405849509543675.

Ladson-Billings, G. (2023). "Yes, but how do we do it?": Practicing culturally relevant pedagogy." In White teachers/diverse classrooms, 33–46.Routledge. https://doi.org/10.4324/9781003448709

Macintyre, H. L., Heaviside, C., Taylor, J., Picetti, R., Symonds, P., Cai, X. M., & Vardoulakis, S. (2018). Assessing urban population vulnerability and environmental risks across an urban area during heatwaves–Implications for health protection. *Science of the Total Environment, 610,* 678-690.

Magwilang, E.B. (2016). Teaching Chemistry in Context: Its Effects on Students' Motivation, Attitudes and Achievement in Chemistry. *International Journal of Learning, Teaching and Educational Research, 15.*

Mawere, M. 2015. "Indigenous Knowledge and Public Education in Sub-Saharan Africa." Africa

Ng'Asike, J. T. (2011). Turkana children's rights to education and indigenous knowledge in science teaching in Kenya. *New Zealand Journal of Teachers' Work, 8(1),* 55-67.

Nzewi, U.M., (2020). Recent Developments in Gender Issues in STEM Education. YouTube. Available online: https://youtu.be/mcbpmMgjis4 (accessed on 22 October 2021).

Okebukola, P. (2020). Breaking Barriers to Learning: The Culturo Techno-Contextual Approach (CTCA). Slough, UK and Delhi: Sterling.

Okebukola, P. A. (2015). Towards the development of the Culturo-techno-contextual approach (CTCA).

Okebukola, P. A. (2019). The Role of Higher Education in Building a Knowledge-Driven Economy.

Okebukola, P., Ige, K., Oyeyemi, A., Olusesi, O., Owolabi, O., & Okebukola, F. (2016). Exploring the impact of Culturo-techno-contextual approach (CTCA) in tackling under-achievement in difficult concepts in biology. Paper presented at the Proceedings of the Conference of the National Association of Research in Science Teaching (NARST). USA: Baltimore.

Oladejo, A. I., Okebukola, P. A., Nwaboku, N., Kola-Olusanya, A., Olateju, T. T., Akinola, V. O., Shabani, J., & Ogunlade, I. (2023b). 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., Okebukola, P. A., Olateju, T. T., Akinola, V. O., Ebisin, A., & Dansu, T. V. (2022). In search of culturally responsive tools for meaningful learning of chemistry in Africa: We stumbled on the culturo-techno-contextual approach. *Journal of Chemical Education, 99(8),* 2919-2931.

Oladejo, A. I., Olateju, T. T., Ahove, M. A., & Suwadu, B. (2024). A beautiful garment from old fabrics: the analogy of culturo-techno-contextual approach for meaningful learning in science. *Research in Science & Technological Education,* 1–24. https://doi.org/10.1080/02635143.2024.2309905

Oladejo, A.I., Ademola, I.A., Ayanwale, M.A., & Tobih, D. (2023a). Concept difficulty in secondary school chemistry: An intra-play of gender, school location and school type. *Journal of Technology and Science Education.* https://doi.org/10.3926/jotse.1902.

Oladejo, A.I.; Nwaboku, N.C.; Okebukola, P.A.; Ademola, I.A. (2021). Gender difference in students' performance in chemistry–can computer simulation bridge the gap? *Res. Sci. Technol. Educ.* 1–20.

Oludipe, D.I. (2012). Gender difference in Nigerian junior secondary students' academic achievement in basic science. *J. Educ. Soc. Res. 2*, 93–99.

Onowugbeda, F. U., Okebukola, P. A., Agbanimu, D. O., Ademola, I. A., Odekeye, O. T., & Olori, E. O. (2023). Reducing anxiety and promoting meaningful learning of biology concepts through a culturally 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., P. A. Okebukola, D. O. Agbanimu, O. A. Ajayi, A. I. Oladejo, F. Awaah, and A. M. Ige. (2022). "Can the Culturo-Techno-Contextual Approach (CTCA) Promote Students' Meaningful Learning of Concepts in Variation and Evolution?" *Research in Science &Technological Education* 1–17. https://doi.org/10.1080/02635143.2022.2084060.

Perin, D. (2011). *Facilitating Student Learning through Contextualization. CCRC Brief. Number 53. Community College Research Center*, Columbia University.

Rushiana, R., Sumarna, O., & Anwar, S. (2023). Efforts to Develop Students' Critical Thinking Skills in Chemistry Learning: Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA.* https://doi.org/10.29303/jppipa.v9i3.2632.

Saanu, T. (2015). Exploration of the effect of the culturo-techno-contextual approach on the achievement and attitude of students in Logic Gate. Unpublished M. Ed Project Report, Lagos State University, Lagos, Nigeria.

Samson, I., Okebukola, P. A., Peter, E. O., Peter, D. G., Amu, D. O., Awaah, F. A., Oladejo, A. I. (2022). Can the Culturo-Techno-Contextual Approach (CTCA) Break down the Barriers of African Students to Learning Difficult Concepts in Biology? [Paper presentation]. NARST 95th Annual International Conference: Unity and Inclusion for Global Scientific Literacy: Invite as a Community. Unite as a Community, Vancouver, British Columbia. *Spectrum 50 (2):* 57–71. https://doi.org/10.1177/000203971505000203.

Sudarmin, Febu, R., Nuswowati, M., & Sumarni, W. (2017). Development of ethnoscience approach in the module theme substance additives to improve the cognitive learning outcome and student's entrepreneurship. *Journal of Physics: Conference Series, 824(1),* 1–14. https://doi.org/10.1088/1742-6596/755/1/011001

Sunny, C. E., Taasoobshirazi, G., Clark, L., & Marchand, G. (2016). Stereotype threat and gender differences in chemistry. *Instructional Science, 45(2),* 157–175. https://doi.org/10.1007/s11251-016-9395-8.

Utami, B., Saputro, S., Ashadi, A., Masykuri, M., & Widoretno, S. (2017). Critical thinking skills profile of high school students in learning chemistry. *In International Journal of Science and Applied Science: Conference Series (Vol. 1, No. 2,* pp. 124-130).

Vaino, K., Holbrook, J., & Rannikmäe, M. (2012). Stimulating students' intrinsic motivation for learning chemistry through the use of context-based learning modules. *Chemistry Education. Research and Practice, 13(4),* 410–419. https://doi.org/10.1039/c2rp20045g

Wardani, D. K., Martono, T., Pratomo, L. C., Rusydi, D. S., & Hendra Kusuma, D. (2019). Online Learning in Higher Education to Encourage Critical Thinking Skills in the 21st Century. *International Journal of Educational Research Review*, *4(2),* 146–153. https://doi.org/10.24331/ijere.517973

How to cite this article:

Akintoye, H. O., Oludipe, O. S., Oladejo, A. I., Abdulkareem, K. M., Bankole, I., Lameed, S., Onowugbeda, F. U., Benjamin, O. B. A., & Adam, U. A. (2024). Investigating the Impact of Culturo-Techno-Contextual Approach on Enhancing Critical Thinking in Science: Gender Dynamics and Learning Efficacy. *Journal of Educational Sciences, 8(4)*, 656-670.