Journal of Educational Sciences Vol. 9 No. 1 (January, 2025) 305-321

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

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

Revitalising STEM Education: Can Culturo-Techno-Contextual Approach Help to Improve Students' Achievement and Problem-solving Skills in Chemistry?

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ARTICLE INFO

Article history:
Received: 15 Aug 2024
Revised: 03 Jan 2025
Accepted: 04 Jan 2025
Published online: 24 Jan 2025

Keywords:
Chemistry Education
Context-Based Learning
Culturo-Techno-Contextual Approach
Problem-Solving Skills, STEM Education

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Article Doi:
Doi: https://doi.org/10.31258/jes.9.1.p.305-321

A B S T R A C T

This examined the effect of Culturo-Techno-Contextual Approach (CTCA) on students' achievement and problem-solving skills in chemistry. It also captured gender influence as well as interaction effect of method and gender on achievement and problem-solving skills. The study employed mixed methods research design involving the collection of both quantitative and qualitative data. The sample size for the quasi-experimental phase of the study was 102 senior secondary II students selected from three senior secondary schools out of the 14 public and seven private schools. The experimental group comprised 53 students, while the control group consists of 53 students. Difficult Concept in Chemistry Questionnaire was used for the descriptive phase while Nuclear Chemistry Achievement Test, Nuclear Chemistry Problem-solving Skills Test and Nuclear Chemistry Students Interview Guide were used for the experimental phase of the study. Findings revealed a statistically significant effect of CTCA on students' achievement [$F(1,98) = 11.10$; $p < 0.05$] and problem-solving skill [$F(1,98) = 54.52$; $p < 0.05$] but no statistically significant influence of gender on students' achievement using CTCA [$F(1,50) = .07$; $p > 0.05$]. It was recommended that CTCA should be adopted as a method of teaching chemistry globally.

1. Introduction

The global desire to promote Science, Technology, Engineering, And Mathematics (STEM) education may be stirred by environmental and social influences of the 21st century which in turn impedes global safety and fiscal firmness. The difficulty of these global structures reaches beyond just supporting the students to accomplish high scores in mathematics and science assessments (Kelley & Knowles, 2016). The forerunner of economic development and revolution is STEM education. Still, despite the development made in the last two decades, studies have shown that student's interest in STEM disciplines has reduced which shows that students are moving away from STEM disciplines (Habig & Gupta, 2021; Romine & Sadler, 2016; Rozek et al., 2017; Wang, 2013). STEM disciplines are very important in defining the prosperity and success of humanity in discovering and consuming natural resources and expanding the boundaries of invention, supporting the participation of the labour force in the flourishing technological world, and global competitiveness (Kijima et al., 2021; Urban & Favlo, 2016).

Despite the importance of chemistry as an aspect of STEM that is vital for national and global technological advancement, inappropriate methods of teaching and students' poor achievement have become foremost worries to all stakeholders (Ademola et al., 2021). It has been observed that students lack interest in the subject and perform poorly in it because they believe it is difficult (Yurchenko et al., 2022). The lack of problem-solving skills by many chemistry students has also been found to be a problem (Sa-ngiemjit, et al., 2024).

During the last two decades, students' performance in chemistry in both private and public schools external examinations in many African countries has been unimpressive (Afyusisye & Gakuba, 2022; Obadiah et al., 2021). This has been ascribed largely to the manner of delivery of the chemistry curriculum (Chiu & Yu, 2021). For teaching to be effective, it must find its root in mastering how students learn, hence various studies have been conducted to find better customs in which teaching and learning chemistry can be done (Reid et al., 2022, Wenzel et al., 2022). Experienced teachers identify the formation of classroom management as one of the chief goals that need to be achieved during their first visit to a particular class (Ademola et al., 2021). In most Science, technology, engineering, and mathematics (STEM) activities, classroom management is considered to be culturally and contextually relevant.

The Culturo-Techno-Contextual Approach (CTCA) represents the culmination of over 40 years of effort to develop a tool capable of overcoming the barriers to meaningful learning in science education. While various instructional methods, such as cooperative learning, concept mapping, discovery learning, demonstrations, argumentation, mastery learning, and vee diagramming, have shown potential for enhancing the understanding of science concepts, they have largely fallen short in Africa. These methods, whether applied individually or in combination, have not consistently achieved significant and sustainable improvements in meaningful learning due to various contextual challenges. The quest for a more effective and adaptable teaching method led to the development of the CTCA by Peter Okebukola in 2015 (Okebukola, 2020). This approach is specifically designed to be culturally and contextually relevant, addressing several traditional obstacles to meaningful learning in science.

CTCA integrates three foundational elements: (a) the cultural context, which encompasses the societal and cultural environment of learners; (b) technology mediation, reflecting the growing reliance of educators and students on technological tools; and (c) the locational context, which highlights the unique characteristics of each school, including its local examples and case studies, as critical components for science instruction. This fusion of frameworks aims to dismantle traditional barriers and create a more inclusive and engaging learning experience for students in science education. This study sought to solve is the persistent under-achievement of secondary school students in chemistry using CTCA. This study was guided the following questions:

1. How effective CTCA is in improving the achievement and problem-solving skills of students in chemistry?
2. Does gender influence the achievement of students taught chemistry using CTCA method?
3. What are the interaction effects of method of teaching and gender on achievement and problem-solving skills of students in chemistry?

Theoretical Framework

The theoretical bases of this study are Lev Vygotsky's sociocultural learning theory and Ausubel's theory of meaningful learning. The CTCA philosophical framework served as the philosophical basis of the study. Vygotsky's sociocultural learning theory stressed the importance of social and cultural in the learning process. Vygotsky's sociocultural learning theory also upholds that interaction knowledge has to do with collaboration. This type of learning process is known as social constructivist theory because, in Vygotsky's view, the learners must be fully intricate in the learning process. An advance organiser according material to Ausubel's theory of meaningful verbal learning is an assertion preceding a lesson that is designed to observe the material to be learned by the students and connect such to content already in existence in the learner's schemata. The advance organiser can be seen as an instrument used to begin a lesson topic and exemplify the connection between what the students are about to learn and what they have already learned (Ausubel, 2012). The desire Ausubel to ensure students learn meaningfully rather than by rote encouraged him to propose his theory of advanced organiser.

2. Methodology

The study employed the explanatory sequential mixed methods research design involving the collection of both quantitative and qualitative data. The first phase was a descriptive survey of difficult concepts in chemistry, while the second phase involved quasi-experimental research design. This was adopted because the experimental and control groups were sampled in their intact classes.

Population and Sample

A total of 1,292 chemistry students from 14 public and seven private senior secondary schools two participated in the descriptive survey phase of the study. These schools were conveniently selected from Lagos State and Ogun State, Nigeria based on readiness and easy access. Nine public schools and four private schools were selected from Lagos State while five public and three private schools were selected from Ogun State. Private schools represent about 35% while public schools represent about 65%. The participants selected from Lagos State were 765 (59%) and Ogun State were 527 (41%). The percentage of female and male students in the study was 51% and 49% respectively. The sample size for the second phase of the study was 102 senior secondary II (equivalent to 11^{th} grade) students selected from three senior secondary schools out of the 14 public and seven private schools used in this study based on their level difficulty in Nuclear Chemistry. The experimental (CTCA) group comprised 53 students (male = 11, female =42). The control group, 53 students (male =19, female =30). The participants consist of about 29% male and 71% female. About 17% of the participants were between the ages of 12-14, 77% were between 15-17 years and about 7% were above 17 years. To collect the qualitative data, three students were selected randomly for an in-depth interview from the CTCA group.

Instrumentation

Three instruments were used to collect data for this study. The Difficult Concept in Chemistry Questionnaire (DCCQ), Nuclear Chemistry Achievement Test (NCAT) and Nuclear Chemistry Problem-solving Skills Test (NCPSST).

The Difficult Concept in Chemistry Questionnaire (DCCQ) was design and administered at the descriptive phase of the study. DCCQ had five sections. Section A was used to collect demographic data. Section B had 22 topics which were drawn from the new chemistry syllabus used by all schools in Nigeria. The section had a three-point rating scale of very difficult, moderately difficult and not difficult. Section C was used to collect data on the factors influencing respondents' perception of the difficulty of the topics listed. Section D had the list of reasons for the difficulties which was placed on a four-point rating scale of strongly agree (SA), agree (A), disagree (D) and strongly disagree (SD). The fifth section of the questionnaire, E sought the respondents' suggestions for improvement on those topics. Schools that chose Nuclear Chemistry as the most difficult topic in were chosen for the second phase.

The Nuclear Chemistry Achievement Test (NCAT) was self-developed and used to check the academic achievement of students. The instrument has two sections A and B. Section A contains students' demographic data, while B has 35 multiple choice questions (MCQ) with four options each using letters A-D. The Nuclear Chemistry Problem-solving Skills Test (NCPSST) consisted of 16 items; this instrument had two sections. There were 10 items in section A and 6 items in section B. The Nuclear Chemistry Problem-solving Skills Test (NCPSST) was developed by the researchers. The nuclear chemistry students' interview guide (NCSIG) was used to collect data for qualitative analysis. Pretest and Posttest were administered in two phases to ensure the students were not in a rush. The first phase involved administering NCAT to the two groups, and the second phase involved administering NCPSST two days after the NCAT.

The validation of Difficult Concepts in Chemistry Questionnaire (DCCQ) was conducted by a team of 12 science and technology education experts. The Content validity of the Nuclear Chemistry Achievement Test (NCAT) was determined by requesting a group of experts in chemistry education to examine the adequacy of the items and the rating scale. The instrument was administered to 73 students and the data obtained was used to determine its reliability using IBM-SPSS version 23. The reliability coefficient of 0.80 was obtained as the coefficient value of the instrument.

The Nuclear Chemistry Problem-solving Skills Test (NCPSST) was subjected to criterion-related (predictive) validity to ensure the instrument can measure the predicted future problem-solving skills of the students. It was validated by three experts who looked at the adequacy of the items in line with the research questions. Corrections were made where necessary, and then the instrument was administered to SS 2 students in one of the secondary schools in Lagos state. Internal consistency reliability was conducted to check how well the test assesses identical items by correlating scores. Internal consistency reliability also measured the level of consistency among items of a test and with the whole test. The instrument was administered to 46 students and Split-half was used to determine the coefficient value of the instrument through IBM-SPSS version 23. Spearman-Brown of unequal length coefficient value of 0.76 was obtained.

Administration of treatment

Both the experimental and control groups were taught for four weeks. The CTCA group (experimental) was taught following the five steps for implanting the CTCA. The steps below were repeated for each lesson in the experimental group:

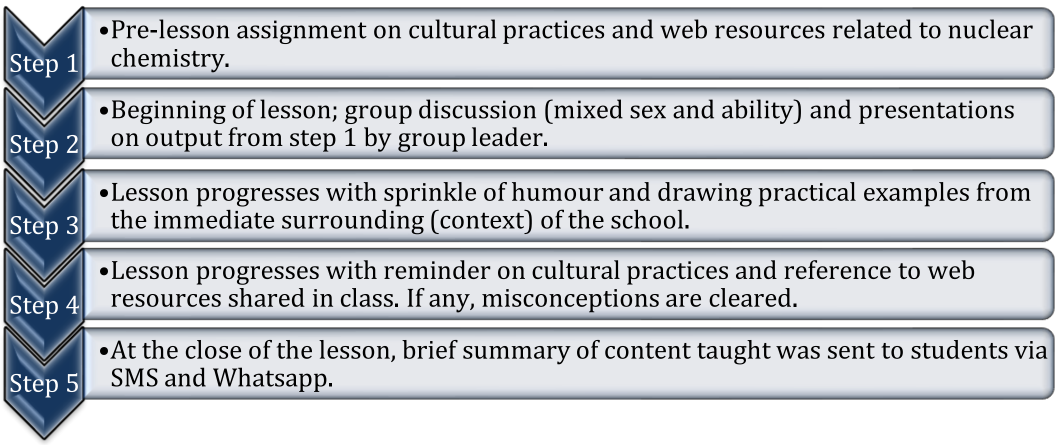

Figure 1. Implementation of CTCA

Step 1: Before the commencement of the lesson the students were asked to

(a) use their mobile phones or Internet-enabled devices to search the web for resources and watch YouTube videos on the topic "nuclear chemistry".

(b) reflect on cultural practices and beliefs associated with the topic "nuclear chemistry".

Step 2: (a) When lesson convened, the students were welcomed to the class and were grouped into mixed-sex and mixed ability level.
(b) Each group was given 5 minutes to discuss the assignment assigned to them prior to the and to select a leader that will present the summary.
(c) The group leaders presented the summary of their 5 minutes discussion on the topic.
Step 3: The topic "nuclear chemistry" was then introduced by the teacher, highlighting examples from the Nigerian culture.
Step 4: Contextual examples were provided, emphasizing some of the discoveries from the student's presentations and further explanation was given on the topic by relating it to day to-day activities. Misconceptions in the presentations of the students were cleared by the teacher.
Step 5: At the close of the lesson, about 320-word summary of the lesson was sent to the students via the WhatsApp group that we created for all the students.
The following Indigenous (cultural) knowledge cases were used to illustrate nuclear chemistry in the experimental (CTCA) group:
Indigenous knowledge used to exemplify Nuclear Chemistry

Case 1

In Africa, drums are made by removing the skin of wild animals which is then exposed to sunlight for some days for the skin to dry up and become very strong. This skin is then used to make any kind of drums depending on the choice of the individual. In Yoruba land, the skin can be used to make drums such as gangan, bembe, apesin, shakara, bata and so on. This concept relates to radioactivity because the animal skin is exposed to sunlight to emit any form of fat or liquid and absorb a large quantity of heat energy before it can then be used for any purpose.

Figure 2: Skin of wild animals

Figure 3: Ilu gangan (talking drum)

Case 2

The word 'Ile' as pronounced in the Yoruba language means 'house' or home while 'Ife' as a Yoruba word means "expansion". "Ile-Ife" is thus in location to the myth of origin as "the land of expansion" or 'house of expansion'. Ife was known to be the capital and principal religious centre of the Yoruba kingdom. The Yoruba race believes that Ile Ife was where light was first detected before it spread to other Yoruba lands. Also, in Africa, especially in Yoruba land, farmers use the smoke of burning fire to know that a fire is burning somewhere then they will go there to tap fire for their use from such location. The detection of rays of light burning from the farm or hut can also be used to know if a farmer is around the hut or on the farm. It is also used to trace a farmer whom one has never met before. The ray of light from the farm or hut in an African setting is also used to indicate a settlement in a place where one has never been before. This scenario relates to radiation.

Case 3

Esusu is an orthodox form of cooperative society in African societies. It includes a team of people who agreed to contribute money and form credit associations and a non-formal savings scheme which is beneficial to all members of the team. These associations are found mostly in agricultural production and credit financing, and they substitute for and complement contemporary cooperative organizations and formal financial schemes. This practice is assumed to have emerged from the Yoruba people of Nigeria and has extended to other West African countries, Liberia, and the Democratic Republic of Congo (DRC) (Warner-Lewis, 1991). However, 'Esusu' practices are built on the trust and honesty of all the members that contribute (Fukuyama 1996; Hofstede 1980).

Esusu (Nuclear fusion)

In Yoruba land, 'Esusu' is a form of cooperative which operates as follows: a team of people will contribute a fixed and equal sum of money at intervals which may be bi-monthly, monthly, weekly, daily or fortnightly. The entire sum of money collected is shared with the members in rotation which sometimes can be through balloting. By the time everyone in the group has benefited from the contribution, a new rotation cycle is inaugurated. Esusu was used to explain nuclear fusion because it has to do with the coming together of people to contribute money.

The control group was also taught the same topic for four weeks, but they were taught using the traditional lecture method of teaching. They were not informed in advance of the topic to be taught as done in the experimental group. The control group was not asked to watch a video or requested to reflect on indigenous knowledge or cultural practices and beliefs related to nuclear chemistry. They were only exposed to the traditional lecture method of teaching without grouping the students or allowing them to discuss anything during the lesson.

3. Results and Discussion

The two data sets (pretest and posttest) scores generated during data collection for the study were analyzed using IBM SPSS version 23 software. The preliminary tests conducted showed that the data satisfied the assumptions of homogeneity of variances [$F = 6.30$; $p > .05$] for achievement and [$F = 1.54$; $p > .05$] for problem-solving skills; Shapiro-Wilk test of normality for the control: (49) = .93, $p < .05$ and experimental group: (53) = .96, $p > .05$ for achievement, Shapiro-Wilk test of normality for the control: (49) = .96, $p > .05$ and experimental group: (53) = .96, $p > .05$ for problem-solving skills. Box's Test of Equality of Covariance Matrices was not significant ($p = 0.12$). After meeting these assumptions, mean and standard deviation, and multiple analysis of covariance (MANCOVA) and One-way ANCOVA were used to analyse the data.

The first research question sought to find out if there is a statistically difference in academic achievement and problem-solving skills between students taught nuclear chemistry using CTCA and those taught using the lecture method.

Table 1. Mean and standard deviation of experimental and control groups

	Teaching method	Mean	Std. Deviation	N
Posttest achievement	CTCA	19.00	5.18	53
	Lecture method	14.63	3.78	49
	Total	16.90	5.04	102
Posttest problem-solving skills	CTCA	12.34	2.06	53
	Lecture method	8.63	2.39	49
	Total	10.56	2.89	102

Table 1 shows that the mean scores of the CTCA group (experimental group) after the administration of posttest achievement (mean = 19.00) and problem-solving skills (12.34) is greater than the mean scores of the lecture group (control group) after the administration of posttest achievement (mean = 14.63) and problem-solving skills (8.63).

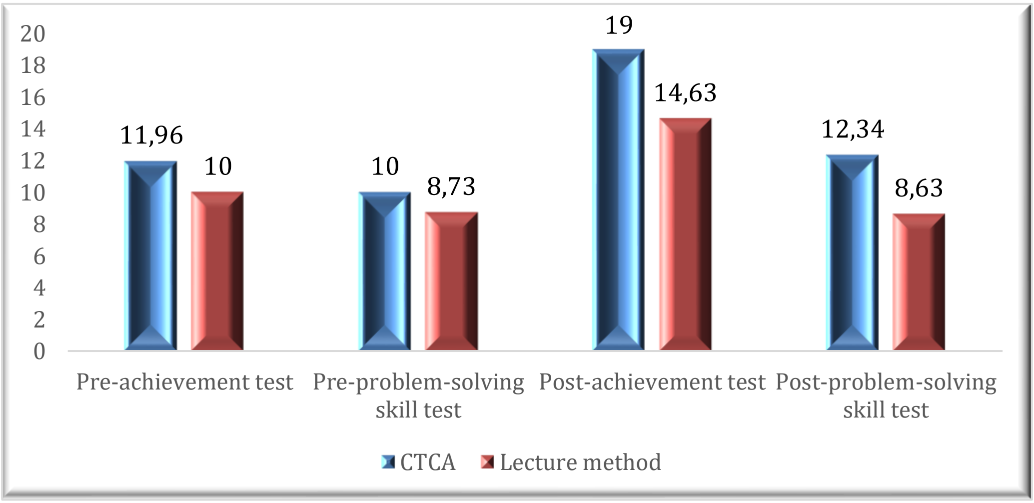

Figure 4. Mean of the Experimental group (CTCA) against the control group

Figure 4 shows differences between the two groups in the pretest achievement and problem-solving skills and the posttest achievement and problem-solving skills. The figure showed that before the introduction of the intervention, the difference in the achievement and problem-solving skills of the experimental and control group is very insignificant. After the introduction of the intervention, the students in the experimental group outperformed their counterparts in the lecture group.

Table 2. Multivariate test of differences in the achievement and problem-solving skills of CTCA and lecture groups

	Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Pillai's trace	.41	33.09[a]	2.00	97.00	.00	.41
Wilks' lambda	.59	33.95[a]	2.00	97.00	.00	.41
Hotelling's trace	.68	33.09[a]	2.00	97.00	.00	.41
Roy's largest root	.68	33.09[a]	2.00	97.00	.00	.41

Table 3. MANCOVA summary table of differences in the achievement and problem-solving skills of CTCA and lecture groups

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Method	Posttest achievement	149.85	1	149.85	11.10	.00	.10
	Posttest problem-solving skill	204.49	1	204.49	54.52	.00	.36
Error	Posttest achievement	1323.04	98	13.50			
	Posttest problem-solving skill	367.61	98	3.75			
Total	Posttest achievement test	31708.00	102				
	Posttest problem-solving skill	12215.00	102				
Corrected Total	Posttest achievement	2569.02	101				
	Posttest problem-solving skill	843.15	101				

The MANCOVA results on the pretest and posttest scores of the two groups showed a statistically significant difference in the achievement [$F(1,98) = 11.10$; $p < 0.05$] and problem-solving skill [$F(1,98) = 54.52$; $p < 0.05$] of students taught nuclear chemistry using CTCA and lecture (see table 3). The multivariate F (Pillai's Trace) [$F= 33.09$; $p < 0.05$] also showed a statistically significant difference in achievement and problem-solving skills between the two groups (see table 2). The partial eta square (.10 and .36 respectively) showed no significant effect. This significance was in favour of the CTCA group see Figure 3 below. No statistically significant difference was found in the achievement and problem-solving skills of students taught nuclear chemistry using CTCA and lecture methods. The second research question sought to find out if there is a difference in the achievement of male and female chemistry students taught using the CTCA.

Table 4. Mean and Standard Deviation of male and female CTCA Students

Gender	Mean	Std. Deviation	N
Male	18.36	5.32	11
Female	19.17	5.19	42
Total	19.00	5.18	53

Table 4 shows that the mean score of the male students in the experimental group after the administration of posttest achievement (mean = 18.36) is very close to the mean score of the female students in the experimental group after the administration of posttest achievement (mean = 19.17).

Table 5. ANOVA summary table of differences in the achievement of male and female students taught using CTCA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	721.379[a]	2	360.69	26.73	.00	.52
Intercept	353.26	1	353.26	26.18	.00	.34
Pre achievement test	715.75	1	715.75	53.05	.00	.52
Gender	.94	1	.94	.07	.79	.00
Error	674.63	50	13.49			
Total	20529.00	53				
Corrected Total	1396.00	52				

One-way ANCOVA results on the pretest and posttest scores showed no statistically significant difference in the achievement of male and female students taught using CTCA; [$F(1,50) = .07$; $p > 0.05$] (See table 5). The partial eta square (.00) which is infinitesimally small also shows no significant gender difference. There is no statistically significant difference in the achievement of male and female chemistry students taught using the CTCA.

The third research question sought to find out if there will be statistically significant interaction effects of method of teaching and gender on achievement and problem-solving skills of students taught nuclear chemistry using CTCA and lecture method. The MANCOVA statistics showed that the interaction effect of the method of teaching and gender on the achievement of the students was not significant [$F(1,96) = 0.72$; $p > 0.05$]. It also showed the interaction effect of the method of teaching and gender on problem-solving skills was not significant [$F(1,96) = 0.28$; $p > 0.05$] (see table 7). This means the interaction of the method of teaching and gender does not determine what the achievement and problem-solving skills of a student will be. The multivariate F (Pillai's Trace) [$F= .48$; $p > 0.05$] also showed that the interaction effect of the method of teaching and gender was not significant (see table 6).

Table 6. Multivariate test results on interaction of method and sex on achievement and problem-solving skills

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Method * gender	Pillai's Trace	.01	.48[b]	2.00	95.00	.62	.01
	Wilks' Lambda	.99	.48[b]	2.00	95.00	.62	.01
	Hotelling's Trace	.01	.48[b]	2.00	95.00	.62	.01
	Roy's Largest Root	.01	.48[b]	2.00	95.00	.62	.01

Table 7. MANCOVA summary table of the interaction of method and gender on achievement and problem-solving skills

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Method * gender	Posttest achievement	9.69	1	9.69	.72	.39	.01
	Posttest problem-solving skill	1.06	1	1.06	.28	.60	.00
Error	Posttest achievement	1296.36	96	13.50			
	Posttest problem-solving skill	366.24	96	3.82			
Corrected Total	Posttest achievement	2569.02	101				
	Posttest problem-solving skill	843.15	101				

Discussion of results

The first research question sought to find if CTCA will be effective in improving the academic achievement and problem-solving skills of chemistry students. The result of the analysis conducted showed a statistically significant difference in the method of teaching through the multivariate F (Pillai's Trace) [F= 33.09; p= 0.00]. Therefore, the null hypothesis was rejected. This significant difference was in favour of the experimental group (CTCA). The result of this study agrees with the findings of Saanu (2015), who also found a significant difference in achievement of students' taught logic gate using CTCA and lecture methods. In the same vein, Egerue (2019) found a significant impact of traditional beliefs on students' scientific explanation of genetics and ecology concepts. This finding is in contrary with that of Nwosu (2023) who found no statistically significant difference in the mean achievement scores of students taught using CTCA and those taught using lecture method.

There are many reasons why the CTCA group performed better than the control group. The culturo-techno-contextual approach (CTCA) group performed better than the control group because they were taught using the CTCA method which combines culture, technology, and context of the school environment. Part of the procedure for using the culturo-techno-contextual approach (CTCA) is the use of a scaffold in line with what was employed by Lev Vygotsky in his study, this served as appropriate assistance given to the students. The students were able to perform a task with the assistance of an elder person and their mates and this helped the students get nearer to mastering the concept. Another reason was that the students in the CTCA group were grouped in such a way that there was mix-ability and mix-sex, this helped the students to share different reflections on the indigenous knowledge and cultural practices and beliefs that are in line with the topic.

The method also makes use of examples around the students which make the topic simpler for the students. The teacher of the CTCA group facilitated the lesson while students fully participated by presenting to their mates what they learned during their interactions with an elderly person, as well as what they watched on YouTube and what they learned from their classmates during their group discussion. The concept was broken down for all the students to understand it. The students in the CTCA group did almost everything that had to do with learning in the group compared to the control group. Self-efficacy is undoubtedly linked to all measures of motivation such as intrinsic motivation, effort, persistence, and help-seeking behaviour (Skaalvik, Federici, & Klassen, 2015). The students in the CTCA group were motivated and this boasted their self-efficacy thereby outperforming their counterparts in the other group.

The second research question sought to find out if there is a difference in the achievement of male and female chemistry students taught using the CTCA. The result of this study showed that there was no statistically significant difference in the achievement of male and female students taught using CTCA. This result agrees with the findings of Ademola, 2023; Ademola et al. 2022; Adam et al., 2024; Oladejo et al., 2021; Onowugbeda et al. 2024 who found no significant difference between gender and attitude of students taught using the CTCA. However, this finding disagrees with the finding of Bhatti et al. (2023) who found a statistically significant gender difference in academic performance of male and female students, with female students outperforming their male students counterparts.

There was no significant difference in the achievement of male and female chemistry students taught using the CTCA because they were all given equal opportunity to learn. The male students were not treated better than the female students and the female students were not treated better than the male students. The male students were not made superior in the class to the female students. Also, the second step of implementing the CTCA indicates that students should be grouped into mixed sex and ability and after their discussion, a leader should emerge who will make a presentation of what they share in their group. The step did not say the leader of the group must be a male or a female. This means the group has the right to choose either and male or a female as their group leader. This shows that CTCA is a method of teaching that allows gender equality without bias to any gender.

The third research question looks for a possible statistically significant interaction effect of method of teaching and sex on achievement and problem-solving skills of students taught nuclear chemistry using CTCA and lecture method. The result showed that the interaction effect of method of teaching and sex was not significant through the multivariate F (Pillai's Trace) [F= .48; p= .62]. Therefore, the null hypothesis which states that there will be no statistically significant interaction effects of method of teaching and sex on achievement and problem-solving skills of students taught nuclear chemistry using CTCA and lecture method was not rejected. The reason for this result is not far-fetched. This result shows that if the method is properly implemented and both the male and female students are given equal opportunity there will be no significant difference. The result shows that the method is favourable to both the male and female students because the method does not influence the results of male students or the results of the female students. This is the reason why the interaction of method and sex will not affect the achievement and problem-solving skills of the students.

Table 8. Responses of students selected randomly on their perception of CTCA

Students' ID	Students' response (unedited)
Student A, Female, 14 years	One of the difficulties I have in chemistry is explanations certain explanations of some topics and I will prefer that others can also be taught using the method used to teach nuclear chemistry.
Student B, Male, 15 years	I enjoyed the lesson because the method used to teach nuclear chemistry relates the topic to the culture.
Student C, Male, 14 years	I like this method because it allows us to make research, ask questions understand, and even relate them to our culture. The use of culture in this lesson allows for a better understanding pic. The method helped me to understand the lesson because it uses illustration.

Table 8 shows the qualitative data collected from the students. We observed that the difficulties students have in chemistry were melted by CTCA. Based on the responses of the students we found that students enjoyed learning chemistry through the use of CTCA as the method allows the students to research the topic by themselves and also relate the topic with their culture thereby making the concept closer to the students.

Statistically, from the quantitative data of this study, we found that the CTCA group outperformed their counterparts in the lecture group because it is a student-centered learning method which allows the students to fully participate in the learning process. It is also evident based on the qualitative data collected as students expressed how CTCA has helped them to solve their difficulties in learning chemistry with ease. This is the reason why the students in the CTCA group perform better than their counterparts in the lecture group because it is a teacher-centered learning method.

4. Conclusion

The study makes use of an approach that responds to science instruction culturally which can be seen as a major input of CTCA to science education literature. In the cause of testing how effective CTCA is in improving the achievement of senior secondary school students in breaking difficulties they face in learning nuclear chemistry we were able to achieve success. This success adds to the already existing teaching methods, and it helps the students in understanding the subject. This study will also boost the quality of teaching and learning since CTCA is a confluence of science, culture, context, and technology. The study will also lead to a decline in the pressure which science teachers experience in communicating science to students by revamping the understanding of the subject and by also assisting in reducing examination malpractice. Since this study has a slant towards indigenous knowledge which cuts across all nationalities and cultures, this study will be of general interest to educators, policymakers, teachers, parents, and indeed all stakeholders in education. This study was aimed at making teaching and learning science meaningful and easy for students using CTCA. It proposes that if teachers teach science using indigenous knowledge related to students' location, learning will be a lot easier.

The result obtained in this study showed that there is no difference in achievement of both male and female students in the experimental and control groups. This is an indication that the study promotes gender equity. It is also no doubt that this study has implications for the achievement of sustainable development goals (SDG) especially goal number 4 which aims at offering quality education and goal number 10 which aims at lowering inequalities. It will also lead to the actualization of Agenda 2063 goal number 2 which is targeted at providing well-educated citizens and skills revolution reinforced by science, technology and innovation and goal number 16 which is centered on the African cultural renaissance with a focus on; (i) values and ideals of Pan-Africanism; (ii) cultural values and African renaissance; and (iii) cultural heritage, creative arts, and businesses.

Within the limitation of this study, we recommend that:

- CTCA should be adopted as a method of teaching globally.
- further study should be conducted on the use of CTCA especially on nuclear chemistry.
- training should be organized for teachers on the use of CTCA.

Ethical Statement

Before the study began, we sought authorization from the principals of the schools selected for the study. Thereafter, we were introduced to the students and briefed them on the study. The research team verified that all participants signed a consent form on the response booklet indicating their written agreement to participate in the study.

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How to cite this article:

Ademola, I. A., Owolabi, T., Oladejo, A. I., Ogundajo, L., Franklin, O. U., Agbanimu, D. O., Peter, E. O., & Ogonenwe, J. I. (2025). Revitalising STEM Education: Can Culturo-Techno-Contextual Approach Help to Improve Students' Achievement and Problem-solving Skills in Chemistry?. *Journal of Educational Sciences*, *9(1)*, 305-321.