Revolutionizing Students' Success: The Dynamic Impact of Cultural-Techno-Contextual Approach on Academic Achievement in Difficult Concepts in Senior Secondary Chemistry

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Abstract

This study investigated the impact of Culturo-Techno-Contextual Approach on students' academic achievement in difficult chemistry concepts. A sequential explanatory mixed method involving a combination of quantitative and qualitative approaches was adopted. The quantitative approach involved a pre-test, post-test, non-equivalent control group quasi experimental design while the qualitative approach involved interview with a sample of 150 senior secondary school year two chemistry learners drawn from three randomly sampled senior secondary schools in Educational District V of Lagos State. Treatment consisted of teaching two difficult chemistry concepts to the experimental groups using culturo-techno-contextual approach while the control group was taught using the traditional lectured method. The research was carried out for eight weeks. Chemistry Achievement Test (CAT) and Interview Guide were used for the data collection after subjected to both content and face validity with the reliability established using K-20 to yield a coefficient of 0.87. The null hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. Results revealed that learners taught using culturo-techno-contextual approach performed significantly better than those taught by the traditional lecture method [F(1,147)=17.46; p<.05]. Also, no significant gender difference existed between performance of students taught using culturo-techno-contextual approach and those taught using the traditional

lecture method [F(1,145)=.31; p>0.05]. Based on the findings of the study as well as the feedback from the interview guide, it was recommended among others that teachers should adopt culturo-techno-contextual approach as an innovative strategy for teaching chemistry to students in senior secondary schools.

Keyword: Culturo-techno-contextual approach (CTCA), Difficult concepts, Electrolysis, Indigenous knowledge, Saponification

Introduction

Teaching science in general must be grounded in indigenous knowledge and customs. According to Utibe (2010), indigenous refers to something that is cultivated or manufactured locally. Native science, or indigenous knowledge, refers to the various ways that tribes have evolved to perceive, think, act, and interpret the natural world as a result of their interactions with it. A comprehensive body of information, know-how, and customs preserved and expanded by rural residents with long histories of connection with the environment can also be referred to as indigenous or local knowledge (Boven & Morhashi, 2012).

These indigenous knowledge systems (IKS) provide an everyday realisation that rewards individuals who live in a given locality. At this level, in Nigeria and most part of Africa, the teacher remains the centerpiece of information on subjects' contents and serves as the major determinant of the quantity and quality of learning that the students enjoy. This is one of the reasons that, for more than two decades, the majority of research conducted in Africa on how to improve science student performance and stop the rapidly declining rate of students' choice of science has concentrated on strategies that science teachers can use to alter this narrative. Sadly, however, no appreciable progress has been shown (Dansu, 2022).

In finding lasting solutions therefore, and in pursuance of the 'Africa we want' as detailed in the AU's agenda 2063, there is need to rethink how 'science story' is conveyed to the students in the classroom. In doing so, the teacher must keep in mind that these students are very sensitive, ask questions at will, filter whatever information that is passed to them, and they do not like to learn the ways their predecessors learnt (Akinola, 2014). However, recognizing these characteristic differences is easy but providing appropriate approaches that can meet the needs of the students and surpass the limitations of the older methods of teaching science in our schools is more tasking and deserves our rapt attention. In most parts of Africa, science learning at the senior secondary school level is delineated into three major subjects: biology, chemistry, and physics.

The study's decision to focus on chemistry was motivated by the students' consistently poor performance over the previous ten years (Ademola, 2020; Oladejo et al., 2022) and the potential role that chemistry knowledge plays in the acquisition of the other two subjects (biology and physics). For instance, the periodic table and its related topics such as compounds, metals, and non-metals, are mainly taught in chemistry in our schools given the dictates of the curriculum. However, the information is essential and serves as requisite knowledge in learning some science concepts in biology (nutrient cycle) and physics (gas laws, radioactivity).

To this end, the need to enhance students' meaningful learning of chemistry has received considerable attention from concerned individuals and bodies across the country. Over a decade, there has been a greater focus on identifying the concepts in chemistry that students find challenging to learn (Agogo and Onda, 2014; Uzezi et al. 2017) and how to make the learning process easier. This is because, according to Okebukola (2021), it is these concepts that students struggle with in all science subjects and that discourage them from pursuing science education. According to a survey study by Ademola (2020), students were asked to explain why they found specific chemistry subjects difficult to understand through interviews. The most common replies revolved around the professors' methods of instruction and the abstract nature of the concepts. This perception creates some level of fear in the students, distorts their interest in learning when the subject chemistry is mentioned and thus, impacts their performance negatively.

Oladejo et al. (2021) observed in a previous study that a significant issue affecting the teaching of STEM topics in our classrooms, especially at the senior school level, is the content-context disconnect. Most teachers seldom ever question why students learn and forget things so quickly. Research indicates that a primary source of students' poor memory retention in scientific classes is the way the material was taught (Akinola, 2014; Okebukola et al., 2016; Onowugbeda et al., 2022). We present science, especially chemistry, to our pupils as if it were all abstract and beyond of their grasp. Teachers talk about atoms, elements, and molecules in the chemistry classroom as though they will soon fall from the sky for the students.

In order to remove obstacles from meaningful science learning, Okebukola (2015) developed the Culturo-Techno-Contextual Approach (CTCA), a way of teaching and studying science. Obstacles include the belief that science is solely for the talented and the fear of science

because of its unique language, a mathematical mindset, a lack of facilities for teaching and learning, and the abstract nature of some subjects. It is a indigenous teaching strategy meant to make things easier. Okebukola (2019). This will support the many worldviews held by individuals from various cultural backgrounds in a variety of conventional domains, not just chemistry. For teachers and students alike, chemistry is an abstract subject perhaps because of the way it is taught and learned, which does not connect it to real-world activities.

Students' poor performance in the subject has been the effect of this. Native American customs and knowledge are not incorporated into the curriculum. Since chemistry governs the environment, as stated by Thornton (2008), this is highly detrimental to the teaching of chemistry. Unknowingly, the abstract science of chemistry is being applied to environmental resources at various levels of human cultures worldwide, within the framework of indigenous knowledge. For instance, the making of locally made soap in Nigeria thoroughly embodies the idea of saponification. Similarly, separation techniques like, sieving, decantation, evaporation, distillation, chromatography among others is also indigenously practiced. These ideas are derived from a wide range of indigenous knowledge systems and customs. Unknowingly, indigenous people practice these and many more chemistry ideas apart from chemistry as a science topic in schools. Thus, it is essential to incorporate indigenous knowledge and practices of the community into chemistry education to refute the myth that the topic is abstract and unrelated to everyday life, hence the study.

Purpose of the Study

The objectives of this study is to:

i. ascertain whether, when compared to the lecture method, the cultura-techno-contextual approach has any effect on students' academic progress in challenging chemistry concepts.
ii. Find out whether this approach (CTCA) affects students' academic performance in challenging chemistry concepts based on their gender.

Null Hypotheses

H_{O1}: There is no significant difference between the mean achievement scores of students taught chemistry with culturo-techno-contextual approach and those taught with lecture method.

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught chemistry with culturo-techno-contextual approach and lecture method.

H_{O3}: There is no significant interaction effect of the treatment and gender on students' academic achievement in chemistry.

Methodology

The **re**search design for this study is an explanatory sequential mixed method (qualitative and quantitative methods). The quantitative aspect adopts quasi-experimental which involves pre-test and post-test non-equivalent design was adopted with one control group and two experimental groups while an interview was used to measure the qualitative aspect of the research. The research was conducted within the educational landscape of Lagos State Education District V, with a focus on Secondary School 2 (SS2) chemistry students in public schools. The population of interest comprised all SS2 chemistry students within this district. The study employed a purposive sampling technique, a method chosen deliberately to narrow down the selection to SS2 science students due to the specific nature of the research focus. In total, three public schools were selected as the study. The rationale behind choosing three schools was to create both a control group and an experimental group, facilitating a comparative analysis of the effects of the educational intervention. These schools were strategically chosen from two distinct zones within Education District V of Lagos State. Notably, one school was selected from the Ojo zone to serve as part of the experimental group, while the other two schools were chosen from the AJIF zone, representing both the control and experimental groups. A total of 150 students from three intact classes of SSS 2 in the selected schools participated in the study. Consequently, the sample comprised 75 male students and 75 female students.

The instruments for this study were two: Chemistry Achievement Test and Interview Guide. The CAT was a 35 items multiple choice test on two difficult chemistry concepts (Electrolysis and Saponification). Questions relating to saponification and electrolysis were selected from the series WAEC past questions (2015-2020). The instruments were subjected to both content and face validity while the reliability was established using K-20 to yield a coefficient of 0.87. The null hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. The Researchers sought for the approval from the Lagos State Education District V authority to have access to the selected senior secondary schools selected for the study. Thereafter, the Researchers went to each school to brief the chemistry teachers about the purpose of the study and informed the students to voluntarily participate in the study. The chemistry teachers in the

experimental schools were trained on how to use the culture-techno- contextual approach by the researchers. Training involves step-by-step guide on how to effectively use the approach which involves collection of local products such as dried plantain skins, palm trees, and cocoa beans, wire, pencil, etc in explaining saponification and electrolysis. Then how the information can be communicated and disseminated through social media platforms such as whatapp, Facebook, etc. Two lesson plans were developed by the researchers, one for the experimental method using the culture-techno-contextual approach and control group using the lecture method. Also, an interview guide was prepared for the experimental group to seek the opinion of the students on the use of culturo techno contextual approach.

The Chemistry Achievement Test was administered to the control and experiment groups before the commencement which lasted for four weeks. This was to determine the level of their understanding and knowledge. The students in the control group were taught the two difficult chemistry concepts used (Saponification and Electrolysis) using the traditional lecture method throughout the four weeks classes while the experiment group where taught using the CTCA method. After the treatment, the researchers administered posttest using same instrument and marking scheme. The interview guide was administered to the experimental groups after posttest to check if the method really motivates them more towards learning chemistry.

Teaching Electrolysis using CTCA

Material used: 6/9 volt battery, two alligator clipboards or insulated wire, two pencils, beaker, piece of thin cardboard, table salt.

1. The students were grouped into smaller groups and were handled by the researchers and the chemistry teachers as assistant researchers.
2. A beaker was filled with warm water and little table salt was added. After that, the pencils' metal sleeves and erasers were taken off, and both ends were correctly sharpened. the pencils served as the electrodes.
3. Next, a piece of cardboard that would fit the beaker was cut to size, and two holes, spaced about an inch apart, were punched through the middle of the cardboard. Subsequently, the pencils were inserted into the beaker through the apertures.

4. Next, an alligator clip lead attached to the exposed graphite (pencil lead) was used to connect each pencil to the battery. cut off an inch of insulation from either end of the wire. To keep the wires in place, they were wrapped around the graphite of each pencil and connected to each battery using tape.

Teaching Saponification using CTCA

The researcher pursuit the students to source for the following local materials such as cocoa beans, plantain skin, palm oil, shea butter, essential oil and honey.

1. The students were grouped into smaller groups and were handled by one researcher and the school chemistry teachers as assistant teachers.
2. In each smaller group, the students gathered the plantain skin, palm trees and cocoa beans in large quantity for few days and then dried under the sun for some days.
3. Then the plantain skin, palm tree and the cocoa beans was burned under low temperature until they turned into ashes. Then, water was added to the ashes and properly mixed and set aside.
4. Then, palm oil was placed on the stove on a low temperature, then the ash mixture was poured in the palm oil as well as the shea butter and was cooked under a very low temperature.
5. The mixture was continuously stirred on the stove in order to get a smooth mixture. Then, honey and Levander oil was added to the soap to give a pleasant scent. The Soap get solidified and float to the top of the liquid and was scooped out with a spoon.

After both experiments, the researchers created a WhatsApp group for the students and a summarized note and assignments was giving to them via WhatsApp. Also, students were free to interact with the researchers at their convenient time.

Results

The null hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance.

$H0_1$: There is no significant difference between the achievement of students taught chemistry with culturo-techno-contextual approach and those taught with lecture method.

Table 1: ANCOVA of the effect of treatments (CTCA) on the achievement of students taught chemistry

Source	Type III Sum of Squares	Df	Mean Square	F	p-value
Corrected Model	1491.989[a]	2	745.994	43.942	.000
Intercept	562.775	1	562.775	34.375	.000
Groups	296.396	1	296.396	17.459	.000
Error	2495.585	147	16.977		
Total	54698.000	150			

Table 1 shows significant difference between the achievement of students taught chemistry with culture-techno- contextual approach and those taught with lecture method This implies that the students taught with cultro- techno-contextual approach did better compared to the students taught with lectured method. Therefore, the null hypothesis which states that there is no significant difference between the mean achievement of students taught chemistry with culture- techno-contextual approach and those taught with lecture method is rejected.

To further confirm the effectiveness of the culture-techno-contextual approach over the lecture method of teaching, the research subjects were interviewed. The responses from the interviewees regarding effectiveness of the treatment were relatively similar. Some of the respondents have the following to say.

> *"I enjoy the method of teaching the researcher used in teaching the content of saponification because it also allows me try new skill with me own ideas and I can make liquid soap and sell to make money. I wish you can encourage my chemistry teacher to start using this method." [student 1]*
>
> *"I have been having problems in that concept of electrolysis especially the calculation aspect, but using this new method called CTCA, I have developed a better perception about chemistry as a subject and I now understand the concept. On my own, I can explain the concept better using that practical we did. After my WAEC next year, I will start selling liquid soap" [student 2]*
>
> *"I do prefer the CTCA method of teaching to the method of teaching used by our chemistry teacher because it is a long-time memory method for me. And with the*

new method of teaching, I can say Chemistry as a subject is an interesting subject and you can make money with it while studying" [student 3]

"I really likes this method because I hates reading for long, I enjoys practical work but my problem with this method is that I don't have a browsing phone as I had to borrow a friend phone to get that write up you sent to our Whatsapp" [student 4]

It can be deduced from the quantitative and qualitative analysis that culture-techno-contextual approach is better than lecture method of teaching chemistry. ``

$H0_2$: There is no significant difference in the mean achievement of male and female students taught chemistry with culture-techno-contextual approach and lecture method.

Table 2: ANCOVA showing the mean achievement of male and female students taught chemistry with culture-techno-contextual approach and lecture method

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1613.702[a]	4	403.425	24.642	.000
Intercept	562.775	1	562.775	34.375	.000
Gender	4.986	1	4.986	.305	.582
Error	2373.872	147	16.372		
Total	54698.000	150			

Table 2 shows no significant difference in the mean achievement of male and female students taught chemistry with culture- techno-contextual approach and lecture method [$F(1,147)=.31$; $p>0.05$]. Interpreting the analysis separately, gender does not affect the performance of the students exposed to treatment. This means that there is no significant difference in the mean achievement scores of male and female students taught chemistry with culture- techno -contextual approach and lecture method.

This result was further affirmed by the outcome of the research subjects' responses on whether gender affects their comprehension and consequent performance in chemistry. The respondents jointly agreed that gender does not influence their level of comprehension when culture-techno-contextual approach was used. This is evident in the responses below.

"I don't think my gender has anything to do with learning chemistry " [student 1].

"My gender is not a problem in learning science but some male students do far better than us. If all chemistry teachers can be friendly and patient like the researcher, then female students will performance better too" [student 2].

"Though I understood the concept but want more explanation of the topic and the calculations" [student 3].

"According to the researcher, CTCA simply means culture- techno- contextual approach i.e using culture and technology to teach science for meaningful learning. No, my gender does not effect in learning science because both male and female students in my group during the practical were eager to learn" [student 4].

The result of the qualitative analysis, indeed, supported that of the quantitative analysis that there is no difference in the comprehension level of male and female students when taught Chemistry using culturo-techno-contextual approach.

HO_3: There is no significant interaction effect of the treatment (culture-techno-contextual approach and lecture method) and gender on students' academic achievement in chemistry.

Table 3: ANCOVA showing the effect of treatments (culture-techno-contextual approach and lecture method) and gender on students' achievement in chemistry

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	1613.702[a]	4	403.425	24.642	.000
Intercept	562.775	1	562.775	34.375	.000
Group*Gender	120.099	1	120.099	7.336	.008
Error	2373.872	147	16.372		
Total	54698.000	150			

Table 3 shows no significant interaction effect of the treatment and gender on students' academic performance in chemistry [$F(1,147)=7.34$; $p<0.05$]. Interpreting the analysis, there is interaction effect of gender and treatment on the academic achievement of students' chemistry concepts.

Therefore, the hypothesis which says there is no significant interaction effect of the treatment and gender on students' academic performance in chemistry is not rejected.

Discussion of the Findings

The findings from the first hypothesis reveals significant difference between the mean achievement scores of students taught chemistry with culturo-techno-contextual approach and those taught with lecture method [$F(1,147)=17.46$; $p<.05$]. The group taught with culture-techno-contextual approach outperformed their counterparts taught with lecture method. This result shows that culturo-techno-contextual approach arouses students' interest, gives the students opportunity to interact and actively be part of the instructional processes which would not have been possible with lecture method of teaching. This outcome supports the previous research by Saanu (2015) and Oladejo (2021), which found that there was a substantial difference in students' achievement scores between the CTCA and lecture methods. This study contradicts the findings of Adeyemi (2020) and Adeosun (2022), who discovered no statistically significant difference between pupils taught the CTCA method and those taught the traditional method in terms of achievement. Since there were 150 total students in this study—100 from the CTCA group and 50 from the lecture group differences in the results between this study and Adeosun (2022) could be the consequence of different sample sizes as a total of 40 pupils were used in each sample by the researcher.

The finding of this study in hypothesis two further shows that there was no significant difference in the mean achievement of male and female students taught chemistry with culture-techno-contextual approach and lecture methods[$F(1,145)=.31$; $p>0.05$]. This is corroborated by the result of Oladejo et al. (2021) work on gender which showed that gender has no significant influence on the achievement of students in chemistry. Also, the finding from this hypothesis is consistent with that of Ishaku (2015), Oladejo (2021) and Omenka (2019) who in separate studies found no statistically significant difference in the mean achievement scores of male and female students in genetics. However, the findings from this study disagreed with the works of Almedu (2015) who examined the effect of gender on the achievement of students in biology using the jigsaw method as the results showed that gender has a statistically significant difference as the male students achieved significantly higher than the female students in Biology when taught using jig saw method. More so, at variance with the finding from the study, Nnamani and Oyibe (2016)

showed a statistically significant influence of gender on students' achievement in favour of the female students.

The non-significant achievement difference in the mean scores of male and female students suggests that CTCA helps to reduce gender differences in achievement. This is not surprising as part of the preliminary steps of CTCA requires the distribution of students into mixed-ability and mixed-gender groups leading to exchange of ideas between members of both sexes in each group. Not only that, CTCA allows for diffusion of knowledge as information gathered from each group is conveyed to the whole class by selected representatives in each group made up of female and male students. Therefore, CTCA has been found effective in improving students' achievement irrespective of their gender as both male & female students equally benefitted from the approach (Oladejo et al., 2021).

Gender differences on achievement could be attributed to other factors such as interest, motivation, attitude, environmental and socio-economic factors which varies from one student to another and is more personal in nature irrespective of their gender. The implementation process of CTCA helps to create equal educational opportunities for both male and female students. It actively involved both male and female students in the teaching and learning process during the course of classroom instruction hereby getting rid of the issue of gender stereotyping. It can therefore be concluded based on the analyzed evidences of this study that CTCA is a potent instructional strategy that can improve students' achievement in chemistry irrespective of their gender (Okebukola et al., 2020; Oladejo, 2021).

The finding from hypothesis three reveals statistically significant interaction effect of method and gender on students' achievement in chemistry difficult concepts [$F(1,145)=7.34$; $p<0.05$ This result is consistent with those of Nwosu and Ndanwu (2020), Omenka (2019), Oladejo et al. (2021), and Ishaku (2015), who discovered no statistically significant interaction between gender and teaching style on student achievement. However, this finding contradicts that of Filgona and Sababa (2017) who found a statistically significant interaction effect of gender and method on students' achievement. It can be deduced that continuous use of CTCA will not only improve achievement in digestive system for all learners, but it will also close the gap in achievement between both genders.

Conclusion

It is clear from the findings that students perform better academically when the researchers used the culture-techno-contextual approach to teach student saponification in secondary school students. This implies the chemistry teacher are expected to improve in their method of teaching for improving the academic performance of chemistry students in school because traditional method has been proven to be ineffective among students through the findings of the study including the structured interview conducted to examine the views of student in the experiment carried in the study. Furthermore, it is evident from the findings of this study that no gender disparity exists in the achievement of male and female chemistry students taught saponification using culturo-techno-contextual approach.

Recommendations

In view of the findings in this study, the following recommendations were made:

1. Chemistry teachers should endeavour to explore different teaching methodologies in teaching chemistry depending on the types of the topics to be taught. This will improve the understanding of students during teaching and learning chemistry concepts.
2. School administrators and curriculum planners should encourage the integration of culturo-techno-contextual approaches in educational curricula to enhance students achievement.
3. Through the use of the CTCA, chemistry teachers can now relate classroom content with the indigenous knowledge of the learners, given them a sense of reality and thereby reducing learning difficulty.
4. Support ongoing professional development for teachers to enhance their understanding of gender-sensitive pedagogical practices and promote inclusivity in the classroom.

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