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Impacts of Culturo-Techno-Contextual Approach on Critical Thinking of Secondary School Students in Learning Difficult Concepts in Physics

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Abstract
This study examined the impact of Culturo-Techno-Contextual Approach(CTCA) on the critical thinking of secondary school students in learning difficult concepts in physics. The study employed a mixed-methods approach. The quantitative approach employed the pre-test, post-test and control group quasi-experimental design**,** while the qualitative approach employed a semi-structured interview for data collection. A total of eighty senior secondary school physics students were selected from a sampled school in Education District V of Lagos state. The research instruments titled Physics Critical Thinking Test(PCCT) and Physics Students Semi-Structured Interview Schedule(PSSIS) were used for data collection. Three research questions were raised and three null hypotheses were tested. The data collected were subjected to one-way and two-way analysis of covariance (ANCOVA) respectively using IBM-SPSS version 23 while the research questions were descriptively analyzed. Findings from this study revealed that CTC Approach has a huge impact on students' critical thinking, it measures success at determining the cognitive effect on students. It also revealed that there will be no statistically significant impact of sex and methods of teaching (CTCA and lecture) on the critical thinking of students in physics difficult concepts. The study further revealed that methods and sex were not statistically significant on the critical thinking of students in physics difficult concepts. Based on the findings it was concluded that the CTC Approach is suitable for killing all illnesses affecting productive and efficient teaching and learning of physics difficult concepts. It was further realized from the study that both males and females will learn at the same pace and either of the two methods will have no effects on the student's critical thinking, so as to improve or deteriorate it. Finally, from the interview conducted, the teachers opined that effective application of the CTC Approach will bring about a massive increase in students' critical thinking, make them be confident scientists and technologists, capable of increasing students' enrolment in physics with improvements in the academic performance of the students. Therefore, it was recommended amongst others that the use of CTCA as an instructional strategy should be explored by physics teachers to enhance meaningful learning of difficult concepts, with physics teachers well trained in content and pedagogy where teachers learn and understand the rudiment and application of CTCA.

Keywords: Culturo-Techno-Contextual Approach, Critical thinking, Physics, Difficult concepts in Physics

Introduction

The complexity of changes, uncertainties, challenges, and problems in today's society are escalating at a rising rate (Barnett & Coat, 2005; Jackson, 2005), necessitating the development of certain talents from its members. With pressures from the social, political, economic, and environmental spheres, this society is rife with disorders, complexity, and ambiguities. Additionally, the job market is fiercely competitive and demands workers who can innovate, respond rapidly to situations, tackle obstacles head-on, and propose solutions to unidentified problems. This kind of culture pushes students to develop the so-called "21st-century skills," which have been dubbed the ability to collaborate, communicate, and think critically, in order to function and make a constructive contribution to the community. Researchers are interested in the topic of teaching critical thinking skills to students and teachers to overcome various learning barriers. According to research, various academics have emphasized the importance of critical thinking skills for learning and comprehending complex ideas as well as for adapting to the hard and constantly changing external environment. Critical thinking was defined by Ahove (2020) as an intellectually disciplined act of engaging the mind to actively and skillfully conceptualize,

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apply, analyze, synthesize, and/or evaluate information obtained from, or generated by, observation, experience, reflection, reasoning, or communication as a guide to belief or action. As noted in the presidential speech of Nigeria on the occasion of her 60th anniversary of independence, many nations have deemed these talents crucial and required for their citizenry to further national development.

According to some academics, critical thinking cannot be formed on its own. According to Ahove (2020), mastery of critical thinking is enhanced if it is developed and evaluated within the framework of a field. Therefore, critical thinkers are required to foster learning so that students may build nations and prepare for any emergency circumstance that may arise. Youngblood and Beitz (2001), who stated that critical thinking can help with insight into the societal conditions causing a patient's illness, supported this by saying that critical thinking can assist with decision-making and an insight into societal conditions generating solutions and way forward. According to Flavell and Wellman (1987), teaching is basically the development of cognition and metacognition and the conviction that critical thinking may be fostered through active learning. According to some academics, critical thinking cannot be formed on its own. According to Ahove (2020), mastery of critical thinking is enhanced if it is developed and evaluated within the framework of a field. Thus, in order to cultivate and grow learners into the nation's future business leaders, and critical thinkers; techniques for active learning are recommended to enhance the growth of critical thought. Because of their cognitive triggering processes, active learning systems encourage critical thinking. In actuality, the development of critical thinking processes and active learning processes are closely related (Youngblood &Beitz, 2001). The ideal critical thinker is persistently inquisitive, knowledgeable, confident in reason, open-minded, adaptable, fair-minded in evaluation, honest in facing personal biases, prudent in making judgments, willing to reconsider, clear-headed in complex situations, diligent in seeking relevant information, and reasonable in their assessments.

The key to attaining this goal of creating superior human resources is education. It takes skilled and knowledgeable educators, as well as a critical, creative, and inventive thinker who will inspire students to comprehend, enjoy, and use Science, Technology, Engineering, and Mathematics (STEM), to generate a technologist or scientist armed with critical thinking abilities. STEM fields are essential for sustainable development because they aid in identifying threats posed by global challenges like climate change, global health epidemics, and rising income inequality (Okebukola,2016). This indicates that learners can acquire the abilities necessary to perform well in today's knowledge-driven society through good STEM education. Science instructors need only a few specialized pedagogical knowledge skills. As a result, science educators need to be better familiar with the various teaching and learning approaches. In general, physics is a fascinating subject, and teaching physics is really enjoyable. According to Onyewuchi (2020), a successful teaching and learning process requires a combination of technology, indigenous knowledge (cultural), and harnessing the surroundings of learners (contextual). He provided examples of various techniques and strategies needed to teach and learn science subjects unconditionally and with love.

The strategies and tactics utilized in the teaching-learning process help students learn more effectively and kindly because they encourage curiosity, which will motivate students to study more and consider its social implications critically. STEM needs to be improved. Lack of self-confidence, emotional instability, a temperamental propensity toward extraversion, and insufficient critical thinking abilities are what have contributed to students' failure. It also suggests that only a small number of students will ultimately be able to pursue careers in higher education that are related to physics. As a result, this will have a significant impact on the development of the engineering workforce and other associated professions. This has also been linked to the slow growth of native languages, which are rarely used for governmental or national purposes. As a result, concerns about pupils' degree of competency in a language other than their mother tongue have been recognised on a global scale. According to Okebukola (2019) this issue has persisted and is still present in higher education. Consequently, universities and colleges in Africa. The English language as a communication medium and science intersect at this moment (Okebukola et al.,2016). Teachers must always clarify scientific principles when teaching science. The integration of proper modes of thinking, the usage of the student's mother tongue, and the appropriate level of scaffolding by the teacher are all necessary for pupils to understand science, just like it is with any other subject (FRN,2004). With the traditional approach (lecture) used by science teachers in Nigeria, none of these have been accomplished because instructors feel unqualified to teach science, and the status of elementary scientific education has long been a matter of concern (Okebukola, 2013).

Statement of the Problem

Different reasons have been attributed to the poor performance of physics students by different scholars. According to Okebukola (2019), there are a number of clear causes for the low enrollment in science courses,

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particularly physics, which has led to a lack of scientists in Nigeria. These causes include poor curriculum delivery, inadequate teacher supply and quality, severely inadequate science teaching facilities, poor student work attitudes, and an overloaded science curriculum. Teaching and learning physics are faced with arrays of challenges, which call for a new approach outside the already existing or conventional methods of teaching physics, that is capable of promoting meaningful learning, increasing academic performance and resourcefulness; determining the impact of the culture-techno-contextual Approach on the delivery of challenging physics concepts in the curriculum, as a study therefore become very expedient.

Purpose of the study

This study aims to investigate the effects of the culture-techno-contextual approach on secondary school students' critical thinking when studying challenging physics ideas.

The objectives of the study are to:

1. Find out the effects of the CTC Approach on students' critical thinking when compared to lectures.
2. Determine whether there is a statistically significant difference between students exposed to CTCA and those exposed to lecture method in Physics based on sex in terms of their capacity for critical thought.
3. Find out whether students feel that CTCA has affected their ability to think critically

Research Questions

1. Is there a statistically significant difference between students exposed to CTCA and those exposed to the Lecture Method in Physics in terms of their capacity for critical thought?
2. Is there a statistically significant difference between students exposed to CTCA and those exposed to lecture method in Physics based on sex in terms of their capacity for critical thought?
3. How do students feel that CTCA has affected their ability to think critically?

Hypotheses

H01: There will be no statistically significant difference between students exposed to CTCA and those exposed to the lecture method in physics in terms of their capacity for critical thought.

H02: There will be no statistically significant difference between students exposed to CTCA and those exposed to lectures in terms of their capacity to think critically.

Methodology

Mixed methods, which include both quantitative and qualitative methodologies, are the design chosen. While the qualitative featured a phenomenological design in which information was collected through interviews, the quantitative involved the use of a quasi-experimental, non-equivalent pre-test, post-test design. This is so that the researcher can utilize qualitative and quantitative statistical tools on the obtained data to produce concrete and trustworthy data from respondents. In his discussion of the benefits of mixed methods for data analysis, Jaiyeola (2020) made the following observations: To (i) improve and strengthen an existing study, and (ii) offer advantages that counterbalance the drawbacks of both quantitative and qualitative research. Therefore, by combining both study designs, the advantages of one methodology can compensate for the drawbacks of the other, and (iii) additional explanation can be provided. In Alimosho Local Government Area of Education District 1 in Lagos State, the population consisted of 100 senior high school physics students from two chosen public senior secondary schools. The 48 male and 52 female students who made up the 100 SS1 science students were randomly chosen from two intact SS1 classes at each of the two public senior secondary schools in the Alimosho Local Government Area of Education District 1 of Lagos State. Eight boys and five girls were among the 13 students who were specifically chosen for the interview. This is due to the fact that throughout the presentation, they acted as a sub-team within the group. The 100 SSS I science students who were chosen at random were split into two subgroups of fifty (50).

The Physics Critical Thinking Test (PCTT) and the Physics Student Semi-Structured Interview Schedule (PSSIS) were the primary research tools used in this study. The test was divided into two sections, A and B. Section A asked questions about the respondents' demographics, while Section B only had four essay questions that measured critical thinking using Bloom's taxonomy. These questions were taken from past West African Examination Council questions and covered the subject of Simple Harmonic Motion, including its definition, applications, terms, energies, and simple calculations. It was graded on a scale of 100, and a marking guide was provided to make grading simple and help responders understand what was actually expected of them. As a result, information from the Physics Critical Thinking Test (PCTT) was evaluated. The researchers created the Physics Critical Thinking Test (PCTT) from the West African Examinations Council (WAEC), an examination body mandated by law in the nation to anticipate the transition of students from secondary schools level to

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tertiary institutions (that is, colleges, polytechnics, universities, etc.). This was done to ensure that the research instruments were valid. As well as colleagues and other research professionals in related domains, the instrument was also examined and improved by a physics expert. Cronbach's Alpha was used to analyze the data with SPSS, and a reliability coefficient of 0.76 was discovered.

Results

Table 1: Mean and Standard Deviation of Students' Critical Thinking Test Scores

	Mean	Std. Deviation	N
Experimental	22.55	8.352	33
Control	18.70	7.090	67
Total	19.97	7.705	100

The mean and standard deviation in Table 1 are varied between the methods used. The method used in the experimental shows more effectiveness than the control regardless of the number of controls. This also shows how poor the method used in the control is. This is further illustrated using a bar graph below. The data collected from the scores of students in physics critical thinking tests was subjected to a one-way analysis of covariance (ANCOVA) using IBM-SPSS version 23. The result is shown in the table below:

Table 2: One-way ANCOVA Table for Students' Scores on Physics Critical Thinking Test

Source	Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	411.96	2	205.98	3.66	.03
Intercept	12028.34	1	12028.34	213.50	.00
Pre-test	85.26	1	85.26	1.51	.22
Methods	374.72	1	374.72	6.65	**.01**
Error	5464.95	97	56.34		**(s)**
Total	45757.00	100			
Corrected Total	5876.91	99			

The One-way ANCOVA results showed a statistically significant difference in the physics critical thinking test of students taught using CTCA and Lecture methods. ($F(1,97) = 0.01$; $p < .05$). Therefore, the null hypothesis **was rejected** since we found a statistically significant difference in the physics critical thinking test of students taught using CTCA and Lecture methods.

Table 3:Mean and Standard Deviation of Students' Scores in Physics Critical Thinking Test

	Sex	Mean	Std. Deviation	N
Experimental	Male	22.39	8.67	13
	Female	22.65	8.37	20
	Total	22.55	8.35	33
Control	Male	19.49	7.95	35
	Female	17.84	6.03	32
	Total	18.70	7.09	67
Total	Male	20.27	8.16	48
	Female	19.69	7.33	52
	Total	19.97	7.71	100

The mean scores in Table 3 above showed female has higher score than male in the experimental group and the opposite in the control group. The total number shows male to female ratio in physics class. This is also represented using a bar chart.

Table 4: Two-way ANCOVA Table for Students' Scores on Physics Critical Thinking Test

Source	SS	Df	MS	F	Sig.
Corrected Model	474.19	4	118.55	2.08	.09
Intercept	11087.69	1	11087.69	194.96	.000
Pre-test	101.86	1	101.86	1.79	.19
Methods	364.19	1	364.19	6.40	**.01**
Sex	5.73	1	5.73	.10	**.75**

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Methods * Sex	37.42	1	37.42	.66	**.42**
Error	5402.73	95	56.87		
Total	45757.00	100			
Corrected Total	5876.91	99			

The F tests showed the effect of Methods and sex on the critical thinking of students.

The result showed that the main effect due to methods of teaching was statistically significant (F (1,95) =6.40; p<.05) thus the null hypothesis was rejected.While the effects due to gender (F (1,95) =0.10; p>0.05) were found to be statistically not significant hence, the null hypothesis was not rejected. The Two-way ANCOVA showed that the interaction between methods and sex was not statistically significant on physics critical thinking test scores of students in physics difficult concepts. Hence, the hypothesis is not rejected. (F (1,95) =.66; p>.05.)

Research Question 3: What opinions do students hold on the impact of CTCA on their critical thinking?

Table 5: Physics Student Semi-Structured Interview Schedule (PSSIS) to know the impacts of CTCA on the students after treatment

S/n	Assumed Names	Demography of students	Interview Responses
1	Taiwo	Female, SS1, 14 years, public school	Yes, it can. It helps us to understand more and more. It is good for everyone. I also wish to be a scientist in the country
2	Ayobami	Male, SS1, 13 years, public school	This method can help to pass exams and I can listen without feeling bored. More students will love it
3	Okoro	Male, SS1, 13 years, public school	It increases our thinking when we are having meetings, it kills our fears of exams. Students will love to do science if teachers can do this.
4	Esther	Female, SS1, 13 years, public school	I like this style, it makes me active and I remember everything we do. It will also help our performance for both boys and girls
5	Deborah	Female, SS1, 13 years, public school	The topic looks hard when we started but it gets easier when we started browsing. It will help a lot of us to understand physics better.
6	Serah	Female, SS1, 12 years, public school	It depends on the students too but I think it is fun and relaxing to learn physics like this.
7	Demi	Male, SS1, 14 years, public school	It aids our critical thinking and I believe we will excel in our exams. Even students from other classes were watching us. Everybody likes the style.
8	Peter	Male, SS1, 14 years, public school	With this, I can do better in other topic in physics and students would love physics if it continues.
9	Ayo	Female, SS1, 14 years, public school	Yes, I will be able to understand other topics. Both boys and girls understand this topic and it will help me in the exam
10	Alani	Male, SS1, 14 years, public school	I had fun, and learned and I can attempt any questions on this. All students love it. I wish to also invent something for human benefit.
11	Ope	Male, SS1, 14 years, public school	It helps our reasoning and I will surely do well in exam. Students will love science with this.
12	Tade	Male, SS1, 15 years, public school	It is good, we all participated, enjoyed it and understand
13	Harry	Male, SS1, 13 years, public school	It is a good method of teaching and we all understand it. It will surely help me to pass my exam and I will be a scientist.

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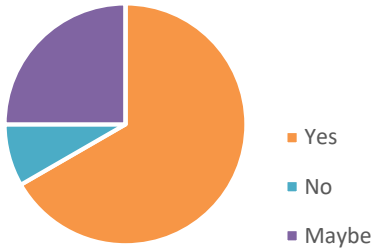
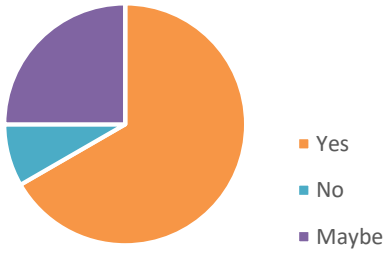
Note: The Figures below show the descriptive analysis from the interview of physics students/respondents in the selected school. Responses were reduced to three level of answer which are 'Yes', 'No' and 'Maybe', the researcher arrived at maybe as some respondents skipped some questions during interview.

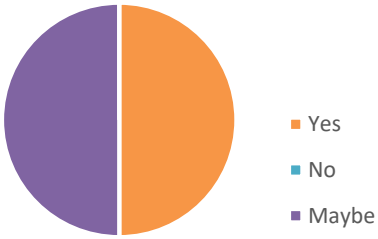
Can CTCA improve students' Critical Thinking?



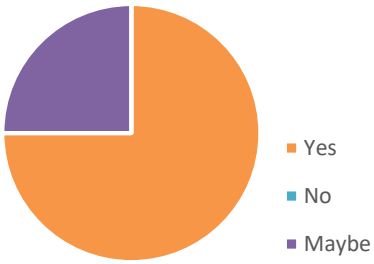
Can CTCA improve enrolment of physics students in the country?



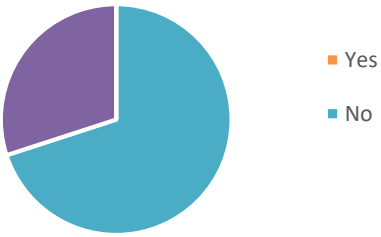
Can effective use of CTCA increases the number of scientists in the country?



Can it improve academic performance?



Does CTCA have gender disparity?



Discussion

The mean scores for the experimental and control groups were, respectively, 22.55 and 18.70, which were both below average. The claim that there would be no statistically significant difference or influence between the CTC approach and lecture approaches on students' capacity for critical thought with regard to a challenging physics idea was refuted. The influence of the CTC approach and lecture approaches on critical thinking is therefore statistically different. The CTC strategy has consistently demonstrated a strong impact on students' academic performance and attitude, according to recent studies (Adam, 2019; Akintola, 2019; Egerue, 2019; Ogunbanwo, 2019; Okebukola et al., 2016; Saanu, 2015). Unquestionably, the CTC approach has had a substantial impact on physics (Onyewuchi, 2020), chemistry (Oladejo et al, 2021), biology (Onowugbeda, 2020; Adam, 2019; Akintola, 2019; Okebukola et al., 2016). Because it manipulates students' cultural backgrounds,

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uses examples from their surroundings, and verifies its validity using technology, the CTC approach emerges as one of the most successful teaching strategies in the twenty-first century. This helps students think critically and become familiar with the issues and solutions in their own lives.

The two-way ANCOVA revealed that neither approaches nor sex had a statistically significant impact on student's ability to think critically about a challenging physics issue. The hypothesis (There will be no statistically significant difference or impact of sex and teaching techniques (CTCA and lecture) on students' critical thinking in difficult physics subjects was therefore not rejected. ($F(1,95) = .66$; $p > .05$). Because of this, there will be no statistically significant difference or effect of sex and teaching modalities (lecture and CTCA) on students' ability to critically think about a difficult physics issue. Women are underrepresented in physics and technology, according to researchers. It was further noted that conflicting school elements such as gender-biased advice and counselling, female students' consistently inferior performance as they advance in grade, and more. It has been established in light of the mentioned observations that some researchers lamented the persistent underperformance of students in science across many African nations (Ibikunle, 2014; Chukwu, 2014; & Johnson, 2012),

Conclusion

It is evident that the CTCApproach is suitable and prepared to be used to cure all illnesses affecting productive and efficient teaching and learning processes in difficult physics concepts. More students are drawn to the CTC Approach because it makes learning engaging and contextual without requiring them to quickly memorize complex terms or vocabulary. Students can readily connect words or concepts (concept mapping) with their current environment or surroundings and find meaningful learning in making the right judgments with the CTC technique instead of the lecture method.

Recommendations

This study showed how studying challenging physics concepts affected secondary school students' critical thinking. As a result, the following suggestions are provided:

1. Teachers should implement the Culturo-Techno-Contextual Approach (CTCA) in their classrooms to maintain quality education and the teaching-learning process for the students and help them develop a relational understanding of STEM subjects, especially physics, as it has been demonstrated to build and develop critical thinking of teachers and students.
2. Administrators and educators should support the adoption of CTCA as one of the 21st-century approaches to removing learning barriers in the teaching of all concepts and in all sectors of learning in an effort to continuously enhance both public and private education.
3. According to teachers, the CTC Approach, when used effectively, significantly improves students' critical thinking skills and gives them the self-assurance they need to succeed as scientists and technologists. Additionally, it boosts enrollment in the physics department. This finding unequivocally demonstrated the beneficial benefits of efficient teaching techniques on students' academic achievement.
4. To improve students' academic performance, critical thinking, retention skills, and inquiry skills, among other things, physics teachers should be encouraged to employ CTCA when teaching physics in secondary schools. To increase the amount of cooperative learning, cultural integration, technology-assisted learning beyond the scope of a given concept, and child-centered instruction, physics teachers should be well-versed in both content and pedagogy. Teachers should learn the basics of CTCA as well as how to apply it in the classroom.
5. The government, school administrators and other stakeholders should work to fully equip the physics lab and improve the mathematical background of pupils, while regular monitoring or reporting must be taken to ensure satisfaction. And make sure there are resources, both human and non-human, that will help with computer learning and application. Teachers should act in a way that does not frighten the students since learning is more effective when people are relaxed. The federal government, through the Ministry of Education, should also provides teachers with the CTC Approach, a strong and flexible multidimensional method that will help pupils feel at home, study more effectively, and lose their fear of physics.

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