

The Culturo-Techno-Contextual Principles to STEAM Education for SDG-4 Attainments

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Abstract

STEAM education is best taught using Culturo-Techno-Contextual Approach (CTCA). Teaching and learning STEAM with the old and archaic paradigm that is traditional, transmission, conventional, non-heuristic and didactic instructional approach is bound to mar the students' learning outcomes, predispose them to low 21st century skills acquisition and low level of employability and entrepreneurship. The CTCA is premised on ethnophilosophy, technophilosophy and contextuality philosophy that engage students with STEAM education via the holistic approach to the construct. CTCA principles of cultural, technological, and contextual integration in STEAM education raises students' ability, values, capability, creativity, critical thinking skills, digital literacy skill and many other skills expedient for the attainment of SDG-4. With copious theoretical and empirical bases, the article thus suggests lecturers accept and adopt CTCA in the Core Curriculum and Minimum Academic Standard (CCMAS) of Nigerian Universities; the university management should organize workshops, seminars, and symposia for the effective and efficient adoption of CTCA in STEAM education which invariably will heighten the SDG-4 attainment.

Introduction

Evidence in research revealed that students have low learning outcomes in the compartmentalized Science, Technology, Engineering and Mathematics in schools. The low learning outcomes in the four fields of study culminates into graduates with low employability and entrepreneurial skills (Obanya, 2021; Okebukola, 2021; Gambari, 2021). It was reported that majority of Nigeria graduates lack digital literacy skills which predispose them to unemployment state. There have been clarion calls to integrate Science, Technology, Engineering and Mathematics in an integrated amalgam of STEM education. The cross-cutting concepts of the four subjects to be holistically taught to effect an all-round individuals' development in STEM. However, a critique of STEM construct lies in its inability to integrate the four interrelated concepts to solve the societal issues and challenges. It was identified that STEM lacks ability, attitudes, capabilities and socio-cultural values needed to transform the society with an ordinary STEM education (Adesina et al., 2023). Thus, the need to incorporate "Arts" into STEM to produce another construct known as STEAM education.

STEAM education is that kind of education that integrate Science, Technology, Engineering, Arts and Mathematics in an

holistic approach towards using STEM to reflect the socio-cultural context and creating ability cum capability in the recipients to the extent of instilling functionability in the socio-cultural environment. The essence of integrating Arts into STEM to generate STEAM makes STEM education take cognizant of the socio-cultural dimensions in Art subjects like social studies, Government, Economics, Cultural and Creative Arts along other socio-cultural issues that affect the environment. The actualization of STEAM educational objectives would be sine-qua-none to the attainment of the Sustainable Development Goal-4 (SDG-4) realization. The SGD-4 enhances educational inclusiveness and quality education.

With the deplorably low learning outcomes in the compartmentalized Science, technology, engineering, arts and mathematics, with the antecedents of students and graduates low 21st century skills attainments and low quality of education and educational inclusiveness, there is an urgent need for a better paradigm of instruction, instructional strategy that can transform the teaching and learning of STEAM education to reflect the socio-cultural, technological and the contextual dimensions of instructional processes, such is Culturo-Techno-Contextual Approach (CTCA) to education. What is this new instructional strategy – CTCA? What is STEAM education? Can CTCA enhance the SGD-4 attainment in STEAM education? These and many other issues shall be unraveled in this article.

STEAM Education

STEAM can be conceptualized as a developing educational paradigm of how the traditional academic subjects of science, technology, engineering, arts and mathematics can be structured into amalgam or framework which provides a platform for integrative curricula. The approach involves epistemological analysis of general and discipline centered developments hand in hand with the individual subject standard viz-and viz holistic intention of education.

The collection of epistemological narratives from educational philosophers and experts created a ground for integrated curriculum of STEM education. Ulich (1947) credited Socrates and Aristotle with the concept that the pursuit of knowledge is the highest good and that this is the basis of education. STEM movement could be credited to Descartes who averred in the early C17th that the goal of education should be to 'examine all things ...including falsehoods, to know their value (Descartes, 1947). Collection of ideals from these early educational philosophers till the contemporary era provided a fertile ground for understanding STEAM education and its adaptability to change in education in our society.

The fields of science, technology, engineering, art and mathematics are important to the general acquisition of knowledge and development of balanced citizenry. Thus, a framework for giving structure to practice and study of the formal field of science, technology, engineering, mathematics and the arts is STEAM education.

Based on STEM paradigm, STEAM can be conceived in two ways, viz

1. In a more traditional way, STEM education naturally evolves to formally include individual element of science, technology, engineering and mathematics education within their own standards and practices.
2. STEM education covers teaching and learning practices where the subjects are integrated with one another forming

the domain base for other or all may be mixed unilaterally.

An approach to teaching known as STEAM education combines Science, Technology, Engineering, Arts, and Mathematics into a coherent curriculum. The purpose of STEAM education is to give learners a comprehensive, well-rounded education that emphasizes real-world applications and develops their capacity for creativity, critical thinking, teamwork, and problem-solving.

Conventional Instruction Approach

This refers to the classical way of teaching wherein most of the time, lecture method is used by the teacher in delivering the learning content to the learners. The method relies more on use of textbooks, teacher dominating the exercise and is examination oriented. This methodology has been criticized on the ground of being less efficient, non flexible and outdated (Abah, 2020) for the purpose of expanding the frontiers of pedagogy (Oladejo, & Okorie 2022)

The application of conventional instruction approach in educational institutions was adjudged less effective in promoting student performance when compared with the application of the methodology however, the role of the teacher is paramount in whatever pedagogical approach to used in content delivery, out of the myriad of determinants of student academic achievement (Boylan et al., 2016, Donnelly, 2014).

Instructional approach covers the general principles, pedagogy and classroom administration by the teacher (teach.com, 2016). The general method of organizing delivery of instruction and supervision of learners' ability to cope with the learning environment and materials are all embedded in teaching method. Teaching method is grounded in curriculum implementation which facilitates behavioral changes in the learners. This, conventional teaching strategy is about the pedagogical approach employed by the teacher to raise potential in the learners though regurgitation as a sign of proficiency. It is however seen to produce less achievement in the learners (Olagunju & Adesina, 2017; Okebukola, 2021; Obanya, 2021; Adebisi, 2019; Gambari, 2021).

Sustainable Development Goal 4(SDG4)

Sustainable Development Goal 4 is one of the 17 global goals established by the United Nations (UNDP, 2023) as part of the 2030 Agenda for Sustainable Development. SDG 4 focuses on quality education and aims to ensure inclusive and equitable quality education for all by 2030. This goal recognizes the importance of education in achieving sustainable development and seeks to address issues related to access to education, the quality of education and lifelong learning opportunities. It emphasizes the need to provide education that is accessible, relevant, and of high quality to people of all ages, regardless of their background or circumstances, (Hueber, 2018).

UNESCO (2023) identified the official list of indicators to include the following;

Targets of SDG4

1. Universal primary and secondary education
2. Early childhood development and universal pre-primary education
3. Equal access to technical vocational and higher education
4. Relevant skill for decent work
5. Gender equality and inclusion
6. Universal youth literacy and numeracy
7. Education for sustainable development and global citizenship
8. Learning environment
9. Scholarships
10. Teachers and educators

As part of the 2030 Agenda for Sustainable Development, the United Nations adopted 17 global goals, including Sustainable Development Goal (SDG) 4. With a particular focus on education, SDG 4 seeks to provide inclusive, equitable, high-quality education and to encourage opportunities for lifelong learning for all. SDG 4 is officially stated as follows:

The Culturo-Techno-Contextual Approach (CTCA)

It is a model of teaching and learning designed to break down many traditional barriers to meaningful and impactful learning condition which existing teaching methods may not adequately or failed to address. It provides opportunity for educators to gain insight into the nexus between cultural and socio-economic variables and the science education. Barton and Yang (2000) applied the model to science education of Inner city students. It however finds application to educational delivery in Nigeria.

Culture plays central role in science education research. It is significant in research issues bothering on equity among student with income differential background, plural societies marked by ethnic inequalities. It provides a platform to appreciate science classrooms as cultural place and recognize the importance of student cultural differences as resources for science learning (Seiler, 2013). Notwithstanding the gains associated with culture-technological model in Nigeria pedagogical skills appear not to be fully integrated in the teaching and learning of science, technology, education and art disciplines. New development in teaching provides sketchy evidence of its application (Okebukola. 2020) in daily routine of teaching in Nigerian schools.

Culture–techno contextual approach as a model of teaching and learning was designed to overcome traditional hindrance to impactful learning, which the present pedagogical approach was unable to wholesomely address. This paradigm is an amalgam of three interrelated frame works (a) the culture context in which learning takes place (b) the technology-mediation which condition interaction between teacher and learners (c) the locational context which characterize each learning environment in terms of geography, environmental nuances and uniqueness.

Since the middle of the C19th, quest for more effective ways to improve performances has generated a lot of research

innovations consequently, different teaching and learning styles which included co-operative learning (Gillies, 2016), concept maps (Schroeder et al, 2018), demonstration (Ho et al., 2016), among others have been thematically discussed in the extant literature. Despite the use of these approaches in teaching learning process, their resultant effects on learning outcome have been debatable (Canning et al, 2018)

Culture has long been employed in education research in different subjects. The classroom is seen as a cultural space and the cultural of the learners is regarded as a foot for learning (Seiler, 2013). Nigeria is a polyglot state characterized by multiplicity of cultural traits. The nation's cultural values encompass age long traditions, norms, values and wealth of knowledge which address topics to be learnt in class. To ensure effectiveness, teachers inform the learners topic to be taught ahead of the lesson period in order for them to make inquiry about the cultural perspectives of the topic from home. This was succinctly described by Awaah (2020) as Afro-centric model.

Teaching students within their cultural milieu encourages learners to comprehend better. It was in this light that Okebukola (2020) conceptualized culture-techno contextual approach (CTCA). The Culturo-techno-contextual Approach (CTCA) is a teaching method based on culture, technology and context. Kwame Nkrumah's ethnophilosophy for culture, Martin Heidegger's technophilosophy for technology and Michael Williams contextualism for the contextual element of CTCA are the relevant philosophies on which the method is based (Okebukola, 2020). According to him, Ethnophilosophy is the study of indigenous philosophical systems. That a society's culture might have a philosophy that does not apply to all people and civilisations worldwide while sharing parallels with other cultures (Awaah, 2021). The CTCA asserts that teaching African students using their culture is imperative since non-African methods do not always apply to their specific living conditions (Okebukola, 2020). In using the CTCA, he asserts that students are encouraged to enquire from their parents, guardians and elders in the community on cultural knowledge relative to concepts to be taught in class as prior knowledge before the subject is taught. He argues that to achieve this, the teacher needs to inform the students ahead of time about the concept/topic to be taught before teaching the concept/topic.

The "techno" component of CTCA is based on "Heideggerian" philosophy. For Heidegger, "enframing" (Gestell in German) is using technology to turn nature into a resource for efficient use. Based on this philosophy, the CTCA advocates using modern technology available to students (Awaah, 2021). Modern technology like the Internet, personal computers and mobile phones enables students to find information better and makes lessons easily accessible. The CTCA encourages teachers, with the support of parents and educational institutions, to adopt technology to support students' understanding of Courses. This entails the willingness of parents and institutions of learning to provide technology aids such as computers, laptops, internet and other technology support infrastructure to aid teaching and learning. The final leg, on which CTCA stands, the context, is based on Contextualism (Okebukola, 2020). Contextualism asserts that our acts, utterances, expressions and learning can only be understood in the context they occur (Okebukola, 2020). Therefore CTCA posits that in teaching students, the materials should be relevant to their immediate environment in order to quickly understand the concepts being taught (Okebukola, 2020). The approach links learning and communities with the main goals of increasing student engagement, boosting academic outcomes, impacting communities and promoting appreciation of the surrounding world.

The goal of the Culturo-Techno-Contextual method is to establish a relevant and inclusive learning environment where students may apply technology, appreciate cultural diversity, and solve real-world problems while deepening their understanding of STEAM ideas. It highlights how crucial it is to provide students with the technical know-how they need, but also with the flexibility, teamwork, and application of that knowledge in a variety of contexts.

Theoretical Framework of CTCA

Vygotsky's Sociocultural Theory

Sociocultural approaches to learning and development were first systematized and applied by Vygotsky and his collaborators in Russia in the year 1978. To them, human actions occur in their specific cultural contexts, with this, human behaviour is easier and better understood vis-à-vis his cultural background. The spread of Vygotsky's thoughts and the usage of his work in different national backgrounds have contributed to "a multifaceted related but heterogeneous proposals" (Rogoff; Radziszewska, & Masiello, 1995).

Sociocultural theory is an up-and-coming theory in psychology that examines the vital roles which the society contributes to human development. It lays emphasis on the importance of interaction between the developing people (younger ones) and the culture in which they live. The theory states that children learn from social interaction within a cultural context. It also acknowledges the relevance of culture and social interaction in formal education. It is of the view that children are products of their social and cultural environment, and stresses how social and cultural influences have effect on children's thinking and learning.

Gredler's (2014) views on the work of Vygotsky establish culture as a basis of cognitive development – a stance reflective of the cultural component of the CTCA. The person in society aims to adapt one's culture's symbol systems to create similar thinking (ontogeny). Here again, the position of Vygotsky, as reflected in Gredler's work (2014), finds a linkage to the cultural component of the CTCA as espoused by Okebukola (2020). Vygotsky highlighted a second critical role: helping people in mastering complicated cognitive skills that are not completely formed until puberty (Gredler, 2014). These skills, according to Gredler, are voluntary (self-regulated) attention, categorical perception, conceptual reasoning and logical memory, which Vygotsky refers to as complex or higher cognitive processes. This component of Vygotsky's theory relates to the first step of Okebukolas' CTCA, where cultural knowledge is expected to be harnessed from the elderly, self, relatives, friends and the immediate environment.

Gredler argues that Vygotsky equated better cognitive functioning, cultural development of conduct and mastery of one's behaviour through internal processes, which is particularly significant. Higher cognitive processes, which need self-mastery, emerge from biological activities through a complicated dialectical process. The process necessitates the child's mastery of external cultural reasoning resources, which become internal thinking mechanisms; reflective of the context component of the CTCA.

Vygotsky's theory foreshadowed later talks about the need to produce self-regulated learners who can guide and govern

their learning and thinking. In contrast to these viewpoints, Vygotsky established two general criteria for developing self-directed thinking, which has had little effectiveness in teaching specific self-regulatory techniques for specific situations. Firstly, learners gain conscious awareness and control over their mental processes before higher cognitive capabilities arise. Secondly, school education should emphasise the development of these broad talents, leading to self-control development.

The social connection between the learner and a competent adult is critical to cognitive growth. Higher cognitive function development is influenced by scenarios in which an adult directs the learner's attention, concentrates their perception, or leads the learner's conceptual thinking. According to the formal definition, any higher cognitive function, such as self-regulated attention, categorical perception or conceptual thinking, was initially externalised as a social connection between two persons. It is then internalised as an intra-cognitive function resulting from the learner's action.

Connectivism Theory

Connectivism was first introduced in 2004 on a blog post which was later published as an article in 2005 by George Siemens. It was later expanded in 2005 by two publications. Siemens' *Connectivism: Learning as Network Creation* and Downes' *An Introduction to Connective Knowledge*. Both works received significant attention in the blogosphere and an extended discourse has followed on the appropriateness of connectivism as a learning theory for the digital age. Both theorists believe that technology has changed the way we receive and share information, thus changing learning as well. This theory explains the effectiveness and significance of technology as the second leg of CTCA in the contemporary world of learning.

Collaboration has been one of the main focal points in education in recent years, especially after the COVID-19 pandemic when people had to isolate themselves and lose physical connection with their peers. A relatively recent learning theory called connectivism suggests that students should gather ideas, theories, and general knowledge from different sources but combine them correctly. Connectivism learning theory focuses on collaborative learning through technological, social, and cultural undertones which are the major legs which CTCA stands on.

Connectivism is a theoretical framework for understanding learning in a digital age. It emphasizes how internet technologies such as web browsers, search engines, wikis, online discussion fora, and social networks contributed to new avenues of learning. Technologies have enabled people to learn and share information across the World Wide Web and among themselves in ways that were not possible before the digital age. Learning does not simply happen within an individual, but within and across the networks. According to the theory, one doesn't learn individually but rather socially. This means that students learn more effectively when they interact with others, and they benefit from shared opinions, ideas and experiences. Still on the theory, humans are social beings and that our beliefs are shaped through our culture and the society we live in, and so is our learning. What and how we learn are affected by the traditions, values and customs of our community. This is the cultural leg of CTCA. According to Okebukola (2020), students will grasp topics better if taught in their cultural context. The notion of cultural teaching methods is that teaching students new concepts with familiar systems will make grasping the concepts easier. So, we have to consider everyone's cultural and social

environment when designing learning experiences. Nevertheless, when we receive large amounts of information at any given moment, our perspectives about things are altered the more we learn about them especially in the digital world. CTCA is a teaching and learning method (technique) that removes conventional obstacles to effective learning.

Thorndike's Connectionism Theory

Thorndike's connectionism is a theory of learning and behavior that was proposed by Edward Thorndike, an American psychologist, in the late 19th and early 20th centuries. The theory posits that all behavior is the result of a connection between a stimulus and a response, and that these connections are strengthened or weakened based on the consequences of the behavior.

At the heart of Thorndike's connectionism is the idea of the "law of effect," which states that behavior that is followed by positive consequences is more likely to be repeated, while behavior that is followed by negative consequences is less likely to be repeated. This principle forms the basis of the reinforcement theory of learning, which is widely used in psychology and education today.

Thorndike's connectionism also emphasizes the importance of context in shaping behavior. According to the theory, behavior is always specific to a particular situation, and the strength of the connections between a stimulus and a response can vary depending on the context which they occur. For example, a behavior that is reinforced in one context may not be reinforced in another context, and may therefore not be repeated in the second context. The final leg, on which CTCA stands, the context, is based on, contextualism (Okebukola, 2020). Contextualism asserts that our act, utterances, expressions and learning can only be understood in the context they occur (Okebukola, 2020). Therefore, CTCA posits that in teaching students, the materials should be relevant to their immediate environment in order to quickly understand the concepts being taught (Okebukola, 2020). The approach links learning and location where learning takes place with the main goals of increasing of boosting academic outcomes, impacting communities and promoting appreciation of the surrounding world.

Another important aspect of Thorndike's theory is the idea of "transfer of learning." According to Thorndike, learning in one context can be transferred to another context if the two contexts share similar elements. For example, a behavior that is reinforced in one situation may be transferred to a similar situation in which the same behavior is required. Transfer of learning is an important concept in education, where it is used to design curricula, instructional materials and instructional strategies such as culturo-techno-contextual approach that help students generalize what they have learnt in one context to other contexts, hence, removing traditional barriers to learning and therefore, producing global citizens.

Empirical Reviews on CTCA in Education

Schwartz and Lederman (2002) support using indigenous knowledge systems in the classroom by claiming that many inexperienced teachers teach science in abstraction, making science lessons boring and difficult for students to grasp. Okebukola et al. (2016) argue that teachers who use cultural teaching approaches can break through this barrier. Oladejo

et al. (2022) in their study of nuclear chemistry, found a statistically significant mean difference between the groups indicating that CTCA improved students' performance in nuclear chemistry compared to the lecture method. Also, Onowugbeda et al. (2022) in a study of variation and evolution in biology, found that the 76 of the students in the experimental group who were taught variation and evolution with CTCA performed better than their control group counterparts. Awaah et al. (2021a, b, c) compared the lecture method and the CTCA in the study of public administration. The result showed a statistically significant difference in the achievement of the experimental and control groups in favour of the CTCA.

In a survey of the impact of the CTCA in tackling under-achievement in difficult concepts in Biology, Okebukola et al. (2016) found a significant difference between the achievements of

students taught with the CTCA and the lecture method, providing a basis for the efficacy of

CTCA and validation of its potency. Further, Adam (2019) discovered that the CTCA impacted student achievement and attitude toward mutation and variation in Biology. He found that the CTCA substantially influences accomplishment, as experimental group students outperformed their control group peers on the achievement measure. Indigenous knowledge must be included to bridge the gaps and voids that pupils experience in their thoughts (Awaah et al., 2021).

Adeosun and Oladejo (2022) investigated on the efficacy of culture – Techno-contextual approach in improving students' comprehension of concepts in Biology in their traditional background attributed to complexity, misunderstanding and misinterpretation of concepts which are used in the topic. The study made use of survey and experimental phase. The sample was drawn from 60 SS 2 biology students. A pretest was administered before the treatment to determine the students pre-existing knowledge of the subject matter in both experimental and control groups; (14 males and 15 females) was taught using CTCA. The research instrument was subjected to a reliability test using the split-half-method. The reliability coefficient was established to be at 0.75. The result showed that there was statistically significant difference in achievement of both the experimental and control group. Students' perception on the use of CTCA as a teaching method in the classroom was generally positive. It was tentatively recommended that CTCA should be adopted by secondary school biology teachers in digestive system.

Abdulhadi et al. (2023) carried out research on the culturo-techno-contextual approach and students' understanding of computer science education in developing economy, using lecture method with teaching method such as flip learning, cooperative learning and simulations to establish it and this holds the key to students' understanding of the concepts. The study made use of quasi-experimental design to determine the efficacy of the CTCA in breaking difficulties related to the study of spreadsheets as a difficult concept in the Nigerian computer science education curriculum. Junior high school students were used in the study. The control group had 30 students with 35 students in the experimental group. The experimental group was taught using CTCA while the control group used the lecture method. The spreadsheet achievement test, which had 40 items on the spreadsheet, was used to collect data. The results showed that the experimental group significantly outperformed the control. The findings showed the potential of CTCA in improving students' performance in spreadsheets in computer science education curriculum.

Adewusi (2020) added that students must develop a sense of cultural belonging to succeed in school. Their findings support (Wilson, 1981) that a particular context must be gathered from the local environment to achieve inclusive learning and a positive behavioural change in the learner's life for successful teaching. Learners better understand topics by questioning elders, relatives, tribes' people and friends about traditional practices related to the notion of bureaucracy in their local surroundings. Finally, Egerue (2019) warns students not to let traditional and religious views interfere with scientific explanations. In today's world, when students may be enticed to compromise the scientific world by favouring indigenous knowledge, Egerue's (2019) viewpoint is timely.

Adewusi et al. (2023) studied retention learning of students in machine language; what can culture-techno-contextual approach (CTCA) do. They made use of lecture method. The retention of information by male and female students taught machine learning using CTCA and the interaction effects of gender and the teaching methods on the retention of information by students taught machine learning using CTCA and lecture method. This study employed sequential explanatory mixed methodologies and a quasi-experimental research methodology. A total of 138 learners in senior secondary II participated in the study. The reliability of the machine language achievement test was determined using the split-half method, which yielded a Spearman-Brown coefficient of 0.80. There is a statistically difference in method of teaching. There was not much work done on the lecturers awareness of culture-techno-contextual approach of CTCA in STEAM education. This research work is therefore out to fill the gap that other researchers have not filled.

Conclusion

From the reviewed literature, it could be concluded that the conventional instructional pattern contributed to the students' low learning outcomes, low 21st century skills development which predispose the students to low employability and entrepreneurship. The newly recommended instructional methodology, Culturo-Techno-Contextual Approach (CTCA) by the Nigerian universities Core Curriculum Minimum Academic Standard (CCMAS) has both the theoretical and the empirical antecedents to enhance and empower STEAM education. Thus, it could be suffice to conclude that CTCA adoption in STEAM education will invariably enhance the Sustainable Development Goal-4 (SDG-4) attainment.

Suggestions

For an effective and efficient implementation of Culturo-Techno-Contextual Approach (CTCA) in STEAM education, for the attainment of Sustainable Development Goal-4 (SDG-4), the following are suggested:

- i. Lecturers should accept the new instructional paradigm by adopting CTCA in STEAM education for enhanced and empowered SDG-4 attainment;
- ii. The universities management should train and retrain the teaching staff on the new methodology (CTCA) for its effective and efficient implementation;
- iii. The university management should provide infrastructural facilities like adequate network and power supply cum technological gadgets to enhance the adoption of CTCA in STEAM education and other educational programmes.

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