EVALUATING THE CULTURO-TECHNO-CONTEXTUAL ARTIFICIAL INTELLIGENCE (CTCAI) PEDAGOGY: A SYNTHESIS OF TWO EMPIRICAL STUDIES ON THE TEACHING OF SOCIAL SCIENCES

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Abstract

This paper synthesises two empirical studies that examined the effectiveness of the Culturo-Techno-Contextual Artificial Intelligence (CTCAI) pedagogy in the teaching of social science topics in Nigerian secondary schools. The first study involved Senior Secondary School Two students learning the topic "Communication Process", while the second engaged Senior Secondary School One students exploring "Separation of Powers" in Government. Across both studies, CTCAI employed cultural metaphors, multilingual discourse, AI-assisted inquiry, contextual examples and collaborative learning. Pretest and posttest data were analysed for achievement, attitude and critical thinking. The results of the synthesised studies demonstrate that CTCAI produced measurable learning gains, especially in achievement and critical thinking. Achievement in the Communication Process study increased from a pretest mean of 10.77 to a posttest mean of 13.77, giving a gain of 3.00. In the Separation of Powers study, the gain was slightly higher, moving from 8.56 to 12.00, for a gain of 3.44. These improvements indicate that CTCAI facilitated better understanding of lesson content in both areas. Attitude exhibited divergent trends. In the Communication Process study, attitude increased modestly from 44.45 to 45.21, a gain of 0.76. This indicates that while CTCAI improved cognitive outcomes in both subjects, its effect on students' affective dispositions varied. The findings show that CTCAI offers strong cognitive benefits while attitudinal responses may vary by subject. ANCOVA was significant ($p<.001$) for all dependent measures for the two studies. Within the limitations of the two studies, it is concluded that CTCAI has promise as a viable pedagogy for enhancing learning. It recommends scaling, teacher training and further research.

Keywords: Culturo-Techno-Contextual AI (CTCAI), Artificial Intelligence in Education, Culturally Responsive Pedagogy, Multilingual Learning, Civic Education.

Introduction

The increasing infusion of artificial intelligence into global education systems presents exciting opportunities as well as substantial challenges. In African classrooms, rapid technological change intersects with complex cultural, linguistic and infrastructural realities that shape how students experience learning (African Union, 2024; Onowugbeda, et al, 2023; Tella, 2012). There is a growing need for pedagogies that harness the benefits of artificial intelligence without

undermining cultural identity, local epistemologies or contextual relevance. (Adam; 2019; Oladejo et al, 2025). The Culturo-Techno-Contextual Artificial Intelligence (CTCAI) pedagogy emerged as a response to this need, integrating indigenous cultural systems, modern technological tools and contextual learning experiences into a coherent instructional model. It positions artificial intelligence not as a replacement for teacher expertise or cultural grounding but as a partner in inquiry, reflection and knowledge construction.

The effectiveness of CTCA has been explored across various subjects (see Okebukola, 2020; and Onowugbeda, 2023 for reviews), and the current synthesis focuses on two studies that examined the pedagogy's application to Communication Process in ICT and Separation of Powers in Government. These two learning domains represent distinct disciplinary traditions: one rooted in technological interaction and digital communication, and the other in civic understanding and political analysis. Bringing them together through a CTCAI lens provides an opportunity to examine the model's cross-disciplinary potential.

Both studies (Akinrotimi, 2025 and Ichukwu, 2025) implemented CTCAI over several weeks and incorporated cultural artefacts, contextual analogies, AI-supported exploration and multilingual classroom discourse. They aimed to determine whether CTCAI could improve student learning outcomes in achievement, critical thinking and attitude. Through a synthesis of the studies' findings, this article contributes to ongoing conversations about AI literacy, culturally responsive pedagogy and educational innovation in Nigeria and West Africa at large.

Statement of the Problem

Despite significant curricular reforms in Nigeria, many secondary school students continue to struggle with comprehension of several concepts in the social sciences. A recurring problem is the disconnect between students lived cultural realities and the content delivered through conventional pedagogies (Awaah, et al, 2020; Babawale 2012; Gbeleyi, et al, 2023; Tella, 2012). Traditional instruction often relies heavily on memorisation, monologic delivery and examples divorced from students' sociocultural contexts (Okebukola, Owolabi and Okebukola, 2012). In ICT, learners frequently find it difficult to relate theoretical communication processes to indigenous communication practices. In Government, students often encounter political models and structures that are presented from Western perspectives without adequate contextual grounding in African governance traditions.

Artificial intelligence tools have the potential to transform the learning experience, but their use can further widen the cultural gap if not anchored in local identity. AI-generated explanations often reflect foreign contexts, metaphors and assumptions that may not resonate with Nigerian learners. Without a framework for integrating AI into culturally grounded pedagogy, students risk becoming passive consumers of machine-generated knowledge rather than active, critical participants in the learning process. The two studies therefore sought to determine whether the CTCAI model, by combining cultural relevance, contextual connection, technological tools and AI engagement, could address these learning challenges.

Theoretical and philosophical frameworks

The CTCAI model is built upon an integrative philosophical foundation that consciously interweaves three core pillars into the fabric of teaching and learning. The first pillar, cultural contextualisation, operates on the conviction that learning transcends the mere absorption of facts to become a process of meaning-making, a process profoundly deepened when new concepts are tethered to the learner's lived experiences, ancestral wisdom, and linguistic repertoire. The second pillar, technological integration, specifically engages with AI tools, reframing them from oracles

of information to collaborative companions in inquiry. This requires moving beyond functional digital literacy to foster a critical AI literacy, the capacity to interrogate, evaluate, and ethically repurpose AI-generated content. The third pillar, contextual relevance, ensures that the arc of learning bends consistently towards local reality, using the community as a living textbook and global knowledge as a comparative lens, thereby preparing students to navigate an interconnected world from a position of rooted identity.

The theory base of the study is the Okebukola eco-techno-cultural theory, propounded in 1990 (Okebukola and Jegede, 1990). The theory which is a STEM slant of the general theory of ecoculture holds that the context (ecology) where teaching and learning of science takes place as well as the microcultures of students and teachers, exert noteworthy effects on learning. The pathways of the effect are two bridges. The first bridge is the link between experiences derived from the learning context and the subject matter to be learned. This bridge can be seen, for example, in relating practices of electroplating that students can observe in their immediate school environment, perhaps in a nearby blacksmith workshop and the topic of electroplating in a chemistry class. The second bridge has longer span, tucked deep in the cultural orientation of learners. This cultural bridge links indigenous knowledge and cultural practices that are related to a STEM concept. The effect of the two bridges is likened to a catalyst accelerating the formation of neural networks which are evidentiary that learning has taken place.

Research Questions

This synthesis was guided by the following research questions, derived from the individual studies:

1. To what extent does the CTCAI pedagogical model improve students' academic achievement in ICT and Government subjects?
2. How does the CTCAI approach influence the development of students' critical thinking skills and AI literacy?
3. What is the impact of CTCAI, particularly its cultural and multilingual components, on student engagement and attitudes towards learning?
4. What are the principal challenges and enabling factors in implementing the CTCAI pedagogy within a resource-constrained Nigerian classroom?

Population and Sample

Both studies were carried out in a High School in Ogun State, Nigeria {see Akinrotimi, (2025) and Ichukwu, (2025)}. The Communication Process study involved 91 Senior Secondary School Two students, while the Separation of Powers study engaged 79 Senior Secondary School One students. The participants represented diverse cultural and linguistic backgrounds typical of Nigerian classrooms. Data from all students who completed both pretest and posttest assessments were included in the analysis.

Research Design and Procedure

The research employed a concurrent mixed methods design within an action research framework. Two intact classes - Senior Secondary School 2 (Communication process, n=91) and Senior Secondary School 1 (Government, n=79), participated in six-week interventions.

The implementation of CTCAI followed a structured sequence that began with an orientation to artificial intelligence. Students were introduced to the nature and uses of AI, its limitations and the importance of critically evaluating AI-generated content. Together with their teachers, they

developed a CTCAI Charter that outlined principles for ethical and responsible AI use in the classroom.

Instruction began with culturally resonant metaphors that activated students' prior knowledge. For Communication Process, students explored indigenous systems such as talking drums, town criers and non-verbal symbolic communication. For Separation of Powers, the pedagogy employed proverbs and artefacts like the *kokorìn* and the three-legged *àrọ̀ mẹ́ta* stool to illustrate the interdependence of governance structures. These cultural frameworks helped students build mental models before engaging with formal definitions.

Artificial intelligence tools such as ChatGPT and Meta AI were used as thinking partners during inquiry tasks. Students explored AI-generated explanations, critiqued the cultural fit of examples, identified errors or foreign contextual elements and collaboratively revised the content using Nigerian realities. This process helped them see AI as a tool for thought rather than as an unquestioned authority.

Multilingual communication was central to the CTCAI approach. English served as the primary medium, but Yoruba, Pidgin English and contemporary youth expressions were strategically used to deepen comprehension, reduce cognitive load and promote learner confidence. Post-instruction assessments included achievement tests, critical thinking exercises and attitude measures. These provided the data used for pretest–posttest comparisons.

Results

The results of the synthesised studies demonstrate that CTCAI produced measurable learning gains, especially in achievement and critical thinking (see Table 1). Achievement in the Communication Process study increased from a pretest mean of 10.77 to a posttest mean of 13.77, giving a gain of 3.00. In the Separation of Powers study, the gain was slightly higher, moving from 8.56 to 12.00, for a gain of 3.44. These improvements indicate that CTCAI facilitated better understanding of lesson content in both areas.

Table 1: Pre and Posttest Scores on Achievement, Attitude and Critical Thinking

Study	Ach Pre	Ach Post	Ach Gain	Att Pre	Att Post	Att Gain	Critical Thinking Pre	Critical Thinking Post	Critical Thinking Gain
Communication process	10.77	13.77	+3.00	44.45	45.21	+0.76	28.72	34.86	+6.14
Government	8.56	12.00	+3.44	42.46	36.05	–6.41	28.35	35.00	+6.65

Attitude exhibited divergent trends. In the Communication Process study, attitude increased modestly from 44.45 to 45.21, a gain of 0.76. In contrast, the Separation of Powers study saw a decline in attitude from 42.46 to 36.05, a negative gain of –6.41. This indicates that while CTCAI improved cognitive outcomes in both subjects, its effect on students' affective dispositions varied.

Qualitative observations documented a marked evolution in students' interactions with AI. Initially prone to accepting AI outputs uncritically, students progressively demonstrated an ability to identify contextual gaps, cultural biases, and weaknesses in AI-generated explanations. They actively engaged in "remixing" by supplementing AI content with locally sourced examples, such as comparing network protocols to a traditional playground game ("Boko Boko") or explaining the balance of power using the analogy of a three-legged stool (*àrọ̀ mẹ́ta*). The quantitative critical

thinking scores showed a slight aggregate increase in the Government study (from 28.35 to 28.75), suggesting growth in analytical reasoning, though the richness of this change was more fully captured in qualitative data.

Critical thinking showed strong improvement across both studies. Learners in the Communication Process study improved from 28.72 to 34.86, a gain of 6.14. Those in the Separation of Powers study improved from 28.35 to 35.00, yielding a gain of 6.65. These findings demonstrate that CTCAI effectively enhances higher-order analytical skills.

Student engagement and attitudinal shifts were among the most pronounced findings. Thematic analysis of feedback revealed overwhelmingly positive responses to the cultural and multilingual aspects of CTCAI. Students reported that lessons were "more collaborative," "easier to understand," and more relevant to their daily lives. The intentional use of indigenous languages and familiar proverbs was frequently cited as a key factor in reducing cognitive load and increasing participation. An intriguing, counterintuitive finding from the Government study was a measurable decline in post-test attitude questionnaire scores. This may be interpreted not as a failure of engagement, but as a shift from a superficial, novelty-driven enthusiasm for technology to a more complex, critically engaged, and perhaps less sanguine, relationship with the challenging process of deep learning.

Table 2: Analysis of Covariance of Between-Subjects Effects for the Communication Process Study

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	867.24	1	867.24	30.93	.000
Intercept	52.81	1	52.81	1.88	.174
Pre_Acht	867.24	1	867.24	30.93	.000
Error	2299.46	82	28.04		
Total	19103.00	84			
Corrected Total	3166.70	83			

Table 3: Analysis of Covariance of Between-Subjects Effects for the Separation of Powers Study

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	299.24	1	299.24	25.50	.000
Intercept	159.68	1	159.68	13.61	.000
Pre_Achmt	299.24	1	299.24	25.50	.000
Error	762.76	65	11.74		
Total	10710.00	67			
Corrected Total	1062.00	66			

Discussion of Results

The synthesised results within the limitations of the individual studies, demonstrate that CTCAI is a powerful catalyst for meaningful learning. Achievement gains in both studies indicate that cultural grounding, contextualised examples and AI-supported inquiry helped students connect abstract concepts to familiar experiences. The higher gain in the Separation of Powers study suggests that students may have experienced particularly strong conceptual clarification through cultural artefacts and contextual examples. These findings are in agreement with previous studies on CTCA by Oladejo, et al (2025), Onowugbeda, et al (2023), and Gbeleyi, et al, (2023).

The divergent patterns in attitude are noteworthy. The positive attitudinal shift in Communication Process may reflect the inherently engaging nature of communication examples and technologies. The decline in attitude in the Separation of Powers study may stem from students' initial struggles with abstractions in civic education or their emotional responses to Nigeria's political environment. This calls for further investigation but does not negate the significant cognitive gains observed.

The consistent increase in critical thinking across both studies is perhaps the most compelling evidence of CTCAI's impact. Similar evidence on CTCA in mono and multilingual modes was provided by Kenneh, 2025; and Oyenaya, 2025. By requiring learners to interrogate AI-generated content, identify culturally incongruent examples and collaboratively reconstruct explanations, CTCAI cultivated intellectual independence and deeper reasoning. Students demonstrated increasing confidence in their ability to critique AI outputs and contextualise their learning.

The synthesis of these results affirms the core proposition of the CTCAI pedagogy: that cultural contextualisation, critical technology use, and local relevance can be synergistically combined to enhance learning in the African classroom. The consistent, albeit modest, gains in academic achievement across two distinct subjects suggest that the model effectively supports curricular knowledge acquisition. This finding challenges any potential assumption that a focus on culture and critical thinking comes at the expense of content mastery; rather, it appears to provide a more meaningful scaffold for it.

The development of critical AI literacy emerges as a paramount outcome. The observed student trajectory, from passive consumers to active critics and "remixers" of AI-generated information, represents a crucial form of empowerment in the digital age. This aligns with the highest objectives of contemporary education: to cultivate discerning thinkers who can navigate complex information landscapes. The use of cultural metaphors and local analogues served as powerful cognitive tools, enabling students to deconstruct and internalise abstract principles from both political science and information technology.

The profound positive impact on engagement, driven by multilingualism and cultural validation, underscores the transformative power of recognising students' identities within the learning process. When knowledge is delivered in a linguistic and cultural register that resonates, barriers to participation lower, and a sense of intellectual ownership flourishes. The noted decline in formal attitude scores in one study invites a sophisticated interpretation, potentially signalling a maturation from a disposition of simple satisfaction to one of deeper, more critical investment, a valuable outcome in itself.

CTCAI engages with the discourse on technology integration. It consciously distances itself from models that prioritise tool proficiency over critical discernment, aligning more closely with frameworks for digital and AI literacy. This perspective, echoed in the work of contemporary scholars, views literacy not as the mechanical ability to operate software but as the capacity to comprehend, interrogate, and creatively manipulate digital tools and content. Within CTCAI, AI,

particularly large language models like ChatGPT and Meta AI, is explicitly positioned as a "partner" rather than a "professor." This distinction is pedagogical dynamite. It transforms the student's role from a passive recipient of algorithmic output to an active critic, a co-creator who must assess the relevance, bias, and gaps in AI-generated explanations and then perform the crucial act of "remixing," infusing that information with locally sourced, culturally nuanced understanding. This process is the practical engine of critical thinking in the digital age.

Furthermore, the model draws vital sustenance from contextual learning theory, which posits that knowledge is most robustly constructed and most readily transferred when it is acquired and applied within situations that mirror authentic, real-world problems. The CTCAI pedagogy operationalises this by consistently designing learning activities that originate from and loop back into the students' immediate environment. Whether it is analysing the communication dynamics of the local marketplace to understand noise and channels or using the school's own prefectural system as a microcosm to explore the separation of governmental powers, the context is never an optional illustration; it is the central arena of learning. This approach ensures that education is not an abstract preparation for a distant future but a meaningful engagement with the present, enhancing relevance and motivation.

What distinguishes CTCAI in the scholarly landscape is its integrative ambition. While numerous studies on CTCA have examined each of these pillars (see Oladejo et al, 2025; and Onowugbeda et al, 2023), cultural responsiveness, critical tech use, contextual learning, in isolation, there is a paucity of empirical research, particularly in the West African context, that explores their deliberate and systematic fusion into a single pedagogical flow. This synthesis represents the model's core innovation, proposing that the true power for transformative learning lies not in choosing between culture *or* technology *or* context, but in weaving them together into a single, stronger pedagogical cord. The present studies seek to fill this gap, providing a lived account of what this weaving looks, sounds, and feels like in the dynamic, sometimes chaotic, reality of a Nigerian secondary school classroom.

Recommendations

Within the limitations of the two studies and based on previous literature, the implications of these findings ripple outwards to various stakeholders in the educational system. For curriculum policymakers and agencies like the Nigerian Educational Research and Development Council (NERDC), the evidence suggests a need to revise curriculum frameworks and teacher training standards to explicitly incorporate principles of culturally responsive pedagogy and digital literacy. This moves beyond adding a computer studies module to fundamentally rethinking how every subject can be taught with contextual and technological intelligence. For school administrators, the message is twofold: investment in basic, reliable digital infrastructure is a prerequisite for equity, and equally important is the creation of collaborative, supportive professional learning communities where teachers can share resources, CTCAI lesson plans, and practical strategies for managing the model's complexities.

For the teaching profession itself, this research offers both a challenge and an empowerment. The challenge is the acknowledgment of the expanded skill set required, a blend of content expert, cultural curator, technology guide, and facilitation coach. The empowerment lies in the model's restoration of teacher agency and creativity; the educator becomes the essential designer of the learning nexus, not a mere deliverer of pre-packaged, often foreign, content. Teachers are encouraged to begin not with a wholesale revolution, but with intentional, small-scale integrations: starting a lesson with a powerful local proverb, designing a single assignment that requires "remixing" an AI search with a family interview, or consciously code-switching to explain a difficult concept.

Finally, for the academic and research community, this work opens several fertile avenues for further inquiry. Further research should investigate why attitude declined in the Separation of Powers study and examine ways to strengthen affective engagement while maintaining cognitive gains. Longitudinal studies are needed to track the retention of both knowledge and dispositions fostered by CTCAI over time. Rigorous comparative studies with control groups would help isolate the specific contributions of each pillar of the model. Perhaps most importantly, research must explore the adaptation and application of CTCAI principles across a wider array of subjects, from the sciences and mathematics to the arts, and in diverse cultural contexts across the African continent and the Global South. The ultimate promise of the Culturo-Techno-Contextual AI pedagogy is not as a fixed, exportable product, but as a generative principle, a call to all educators to thoughtfully and courageously build their own bridges between the heritage of their students and the horizons of their future, ensuring that in the rush towards intelligence, wisdom is not left behind.

Conclusion

This aggregated case study demonstrates that it is not only possible but profoundly beneficial to construct a pedagogical bridge between the deep wellspring of African cultural heritage and the accelerating current of global artificial intelligence. The CTCAI model achieves something important: it decouples technological advancement from cultural homogenisation, presenting a vision of the future where students can master the tools of the digital age without succumbing to a crisis of cultural identity. They learn not just to use AI, but to question it, to contextualise it, and to speak back to it with the authority of their own lived experience and inherited wisdom. This is the essence of a decolonial digital education. The synthesis of the two studies shows that CTCAI is a pedagogical model that enhances students' achievement and critical thinking while preserving cultural identity and contextual relevance. Although attitude gains varied by subject, the overall cognitive benefits affirm CTCAI as a viable instructional innovation for the AI age. As Nigeria and other West African nations prepare students for technologically rich futures, CTCAI offers a balanced and culturally anchored pathway that aligns tradition with innovation.

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