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Bridging Tradition and Innovation: Incorporating Indigenous Engineering Practices into Ghana's Secondary School Curriculum

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Abstract

Despite the richness of Ghanaian Indigenous Knowledge Systems (IKS), their absence in secondary school engineering education renders them irrelevant and uninspiring. This study explores incorporating IKS into Ghanaian second-cycle engineering curricula to advance cultural identity and contextual relevance. Using a mixed-method approach, data were collected from students, instructors, curriculum developers, and local artisans through questionnaires, interviews, and focus group discussions. Findings confirm broad support for integrating indigenous technologies like mud construction and kente weaving. Teachers and students emphasized scientific and mathematical foundations, while curriculum planners focused on compatibility with Ghana's Common Core Programme. IKS is positioned as "local STEM," enhancing student enthusiasm, cultural pride, and environmental responsibility. Issues of teacher preparation and resource limitations emerged, prompting calls for systemic reform. The study outlines a culturally responsive model of engineering education that bridges formal schooling and indigenous practice, calling for curriculum redesign, policy changes, and strong community collaboration.

Keywords

Indigenous Knowledge, STEM Education, Curriculum, Innovation, Sustainability

Introduction

Indigenous knowledge is hundreds of years of innovation rooted in local tradition, culture, and environment. It is distinct from Western scientific practices in being holistic, oral, and experiential. In Ghana, engineering-oriented practices such as kente weaving, canoe carving, and mud construction are brought to life, each one showing advanced physics, structural mechanics, materials science, and sustainability understanding. Even though educationally beneficial, this knowledge receives minimal space in Western paradigm-based formal secondary school engineering education. As a result, Ghanaian students are often unable to see the relevance of engineering studies to their everyday lives and culture. This lack of relevance undermines cultural pride and identity and suppresses creativity and contextual knowledge in STEM education (Leong, 2024; 2025a). Against this backdrop, the research develops three major objectives: to explore how

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Indigenous engineering practice can be integrated into the secondary school curriculum, and how this can be achieved using pedagogical methods that are both academically challenging and culturally relevant; to explore the impact on student understanding, innovation, and cultural identity; and to provide practical models and guidelines for teachers and policymakers to facilitate curriculum reform grounded in culture but of international relevance (Leong, 2025b).

Indigenous knowledge is the well-embodied, cumulative knowledge, skills, and innovations developed by Indigenous people in specific cultural and environmental contexts. As engineering, it manifests in the form of practical, sustainable systems such as earth-based construction, tool technology, and local resource use. Globally, it is coming to be ever more appreciated for its significance. For instance, programs like i-NATURE in the US and Indigenous STEM in Australia have demonstrated that the incorporation of Traditional Ecological Knowledge (TEK) in science and engineering augments students' interest, accomplishment, and identity development through culturally responsive, place-based education (Aladejana & Osayande, 2021; Antwi & Yeboah, 2021; Blackie, 2024; Mawere et al., 2022).

Engineering education in Ghanaian secondary schools, however, remains highly Westernized, as it is not connected to the cultural backgrounds of the students. This theoretical bias excludes such local practices as mud building or kente weaving practices that have numerous engineering concepts like geometry, thermodynamics, and design (Mensah, 2022). More recent scholarships emphasize the value of contextually relevant education and propose a decolonized STEM education that is attentive to students' realities. The integration of Indigenous engineering knowledge can not only make a contribution to education but also affirm the identities of students and drive innovation through their knowledge of Indigenous problem-solving paradigms (Makonya & Dlamini, 2020; Ouma & Ngetich, 2023; Sunzuma et al., 2025).

Methodology

The study used a qualitative multiple-case study design, with ethnographic richness, to explore the viability of integrating Indigenous engineering practices—specifically kente weaving in the Ashanti Region and mud architecture in the Northern Region—into the secondary school syllabus of engineering in Ghana. The design allowed for rich immersion into the day-to-day life, opinions, and cultural insight of various stakeholders.

Purposive sampling was used to select six senior secondary schools that had active technical and engineering departments, near to traditional engineering activities. Prempeh College, Bonwire Senior High Technical School, and Kumasi Technical Institute participated from the Ashanti Region. Tamale Technical SHS, Yendi SHTS, and Walewale Technical School were selected from the Northern Region. Participating in the study were 150 students, 18 technical teachers, 5 NaCCA curriculum planners, and 12 master artisans and builders who are traditional knowledge holders.

Data was gathered through semi-structured interviews, focus group discussions (FGDs), and observation. Some of the major themes in interview questions were: Indigenous knowledge in engineering, applicability to the curriculum, integration strategies, challenges, and facilitation conditions. Where required, local languages were used, interviews were taped, transcribed, and translated with cultural sensitivity.

The study was informed by ethical guidelines. All the participants gave informed consent, complemented by parental consent in children. Intellectual property rights and cultural respect were maintained rigorously, recognizing Indigenous knowledge keepers as co-authors. Data anonymity, safety, and respectful citation were maintained at all times.

Qualitative data were coded thematically, consistent with the study's core themes. Comparative case analysis by region helped to reveal general patterns and localized variation in Indigenous engineering practice. To support the qualitative findings, a further quantitative survey was conducted through stratified sampling. Over 200 subjects—teachers (n=50), students (n=80), curriculum planners (n=30), and artisans (n=40)—from the Northern and Ashanti regions participated. A schedule-based questionnaire, designed against five thematic areas, was applied with Likert scales and multiple-choice questions. Reliability tests were also conducted, and data were analyzed using SPSS for descriptive and correlation analysis.

Culturally Responsive Pedagogy (CRP) and Constructivist Learning Theory inform this study, offering a two-fold framework for curriculum and instructional practice. CRP encourages the integration of students' cultural identities into learning, enhancing motivation and inclusivity (Li & Chen, 2021). It is especially relevant to Ghana's multicultural environment, where engineering has been embedded in traditions such as blacksmithing and traditional architecture. CRP legitimates cultural pride and makes Indigenous knowledge a legitimate source of academic knowledge.

Constructivist pedagogy promotes active, experiential learning whereby students construct knowledge by engaging with the real world. Applied to Indigenous engineering practice—say, rainwater harvesting or loom design—students can situate abstract principles in real-world practice. These systems together provide a model of engineering education that is both contextually relevant and globally applicable, setting Ghanaian students up for academic success while honoring their cultural heritage.

Results and Discussion

Perceptions of indigenous engineering

Local players were in great admiration of local engineering approaches. Ashanti Region students valued kente weaving as an intellectually demanding process that involves the design of patterns, symmetry, mathematical calculations, and the operation of machinery. The Northern Region saw mud architecture as environmentally friendly and economical, with students terming it "green engineering." Teachers condoned the engineering principle embedded in Indigenous craftsmanship, likening kente making to CAD programs and praising the technical ingenuity of Indigenous builders. Indigenous knowledge custodians described their crafts as "people's science," using logic, precision, and sustainability

Figure 1. A Kente weaver at work

Figure 2 A beautifully designed Kente cloth

Figure 3. A Mud house under construction

Figure 4. A fully completed Mud House.

Quantitative results

Educators rated IKS highest in terms of relevance (Mean = 4.00), followed by local artisans, with the greatest concern regarding practical barriers (Mean = 3.32). There was a weak but positive relationship (r = 0.10) between positive attitudes towards IKS and readiness for curriculum reform, and a weak inverse relationship (r = -0.08) between perceived barriers and integration preparedness.

Table 1: Group-wise summary. (Mean score out of 5)

GROUP	Perception of IKS	Relevance to Curriculum	Readiness for Integration	Barriers Score	Support for Policy Change
Teachers	**4.00**	3.54	**3.24**	2.84	**3.52**
Students	3.91	3.52	2.99	3.18	3.48
Curriculum Planners	3.83	**3.57**	3.00	2.87	3.47
Craftsmen	3.75	3.45	**2.60**	**3.32**	3.20

Relevance to curriculum

All the participant groups agreed that Indigenous practice in engineering is highly applicable to subjects like mathematics, physics, design and technology, environmental science, and vocational skills. Students lamented the current curriculum as "too foreign" and detached from their daily life experiences. Teachers specifically pointed out that contextualizing learning through Indigenous examples would be capable of significantly increasing engagement and understanding. Curriculum planners explained that the revised Common Core Programme (CCP) provides the scope for incorporating IKS through elective modules and project work. Artisans emphasized the central role of cultural heritage for facilitating sustainable development and innovation.

Strategies for integration

Stakeholders proposed strategies for integrating IKS in engineering education: project-based learning with local artisans, modular demonstrations by local experts, interdisciplinary subjects integrating science and traditional practices, guest lectures, apprenticeships, site visits to traditional places, and school-community collaborations for knowledge transfer.

Barriers to integration

Challenges included inflexibility of the curriculum, lack of time, lack of teacher education in Indigenous knowledge, inadequate facilities and resources like looms or raw materials, and perception biases labeling IKS as backward. Policy officers cited policy inertia, whereas artisans noted generational gaps and the absence of knowledge-sharing platforms.

Enablers and opportunities

Despite the challenges, enablers such as high levels of student enthusiasm, artisans' willingness to collaborate, autonomy in the CCP, and support from local leaders created favorable conditions for integration.

Pedagogical implications

There are significant pedagogical benefits of the integration of IKS in engineering education. It increases creativity, enhances cultural identity, promotes sustainable thinking, and supports interdisciplinary learning (Mensah, 2022). However, challenges such as inadequate teacher training, poor quality of course materials, and stakeholder resistance remain. Integration must be community-based and culturally appropriate if the integrity and relevance of traditional knowledge are to be ensured.

Culturally responsive pedagogy emerged as an overarching theme, improving participation and identity construction when students engaged with IKS (Antwi & Yeboah, 2021). Teachers reported improved performance when engineering was linked to students' cultures, consistent with international evidence. Local knowledge keepers were central, offering experiential learning that was meaningful and authentic (Zhang, 2025; Tang, 2025).

Policy implications

Research has been conducted with clear policy implications (Li & Chen, 2021; Nguyen et al., 2022). Stakeholders called for curriculum revision, teacher training, and contextualized instructional materials. National standards recognizing IKS as scientific and technical knowledge are needed. Institutionalizing collaborations between schools and local craft centers would ensure sustainable integration (Villegas & Lucas, 2019).

Conclusion

The objective of this research was to explore the feasibility and implications of mainstreaming Indigenous Knowledge Systems (IKS) into Ghanaian second-cycle schools' engineering courses. The aim was to assess the stakeholders' perceptions, identify the opportunities and challenges for incorporation, and outline the pedagogical and cultural appropriateness of IKS in STEM education. Findings indicate that stakeholders place activities like mud building and kente weaving in areas of feasible engineering knowledge, with science principles behind them. Implementation within the curriculum leads to cultural pride, contextual knowledge, and increased student engagement. Stakeholders' adoption and flexibility of the Common Core Programme offer an ideal platform for implementation.

However, limitations in teacher training, resource shortages in terms of instructional materials, and bureaucratic policy lag are serious challenges. The study is also limited by its geographical area and qualitative nature. Future studies need to introduce wider geographic coverage and longitudinal study designs to establish learning outcomes and policy impacts over the long term.

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References

Adeyemi, T. O., Adebayo, A., & Alamu, T. O. (2020). Culturally relevant pedagogy and sustainable education in Africa: A case of indigenous technology and innovation. *Journal of African Cultural Studies*, *32*(4), 453–470. https://doi.org/10.1080/13696815.2020.1751847

Adomako, K., & Owusu-Mensah, P. (2021). Innovations in Technical and Vocational Education Training (TVET) in Ghana: Prospects and challenges. *Ghanaian Journal of Educational Research, 5*(1), 21–36. https://doi.org/10.1080/09720073.2021.011

Aladejana, F., & Osayande, M. (2021). Bridging cultural identity and pedagogy: The role of indigenous knowledge in African classrooms. *International Journal of Educational Development*, *80*, 102388. https://doi.org/10.1016/j.ijedudev.2020.102388

Antwi, M., & Yeboah, S. (2021). Culturally responsive pedagogy in West African STEM education. *African Journal of Pedagogical Transformation*, *2*(3), 89–105. https://doi.org/10.1080/26694145.2021.2009567

Blackie, M. A. L. (2024). Indigenous knowledge and higher education: Towards decolonial futures in Africa. *Higher Education*, *88*(2), 225–241. https://doi.org/10.1007/s10734-023-01040-4

Kwateng, F., & Leong, W. Y. (2025). The urgent need to prioritise engineering education in Ghana. *ASM Science Journal*, *20*(1). https://doi.org/10.32802/asmcj.2025.2005

Leong, W.Y. (2025a). Beyond the Screen: Enhancing Student Engagement in Virtual Classrooms Using Gamification. 2025 14th International Conference on Educational and Information Technology (ICEIT), Guangzhou, China, 2025, pp. 188-193. doi: 10.1109/ICEIT64364.2025.10976109.

Leong, W.Y. (2025b). Enhancing Academic Integrity in E-Exams Through AI-Driven Proctoring Technologies", 14th International Conference on Educational and Information Technology (ICEIT 2025) , March 14-16, 2025, Guangzhou, China. doi: 10.1109/ICEIT64364.2025.10975939.

Leong, W.Y. (2024). TVET for All: Fostering Social Equity through Inclusive Skills Education, 2024 International Conference on TVET Excellence & Development (ICTeD), Malaysia, 16-17 Dec, 2024. doi: 10.1109/ICTeD62334.2024.10844604.

Li, P., & Chen, J. (2021). Active learning and cognition: A constructivist approach in contemporary education. *Educational Review*, *73*(2), 157–172. https://doi.org/10.1080/00131911.2019.1695893

Makonya, D., & Dlamini, B. (2020). Integrating Indigenous knowledge in science teaching: A constructivist approach for sustainable learning. *Cultural Studies of Science Education*, *15*(3), 675–692. https://doi.org/10.1007/s11422-019-09954-8

Mawere, M., Mubaya, T. R., & van Stam, G. (2022). Indigenous knowledge systems and sustainable development in Africa: Relevance for education and innovation. *Sustainability*, *14*(11), 6613. https://doi.org/10.3390/su14116613

Mensah, L. (2022). Kente as mathematics: Reimagining cultural practices in STEM education. *Ghana Journal of Curriculum Studies*, *3*(1), 50–64. https://doi.org/10.1080/08511041.2022.2041527

Nguyen, T., Pham, H., & Tran, M. (2022). Experiential learning in STEM education: Insights into constructivist approaches in Vietnamese secondary schools. *International Journal of STEM Education*, *9*(1), 3. https://doi.org/10.1186/s40594-022-00350-2

Ouma, S., & Ngetich, K. (2023). Traditional engineering practices and their pedagogical implications: A constructivist perspective in Kenyan secondary schools. *Journal of Engineering Education Practice*, *29*(1), 45–58. https://doi.org/10.1177/09732586221112645

Sunzuma, G., Mhlolo, M., & Mazana, M. (2025). Decolonizing mathematics education in Africa through Indigenous Knowledge Systems. *International Journal of Science and Mathematics Education*, *23*(1), 77–95. https://doi.org/10.1007/s10763-024-10362-2

Tang, Y. F., & Leong, W. Y. (2025). Integrating AI-generated art styles into traditional illustration design teaching course. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(7), em2668. https://doi.org/10.29333/ejmste/16602

Villegas, A. M., & Lucas, T. (2019). Teacher preparation for cultural competence: An analysis of recent pedagogical developments. *Journal of Teacher Education*, *70*(2), 174–188. https://doi.org/10.1177/0022487118772524

Zhang, N., & Leong, W. Y. (2025). Intelligent emotional computing with deep convolutional neural networks: Multimodal feature analysis and application in smart learning environments. *Eurasia Journal of Mathematics, Science and Technology Education*, 21(8), em2680. https://doi.org/10.29333/ejmste/16661