Research Article

Fostering Sustainable Development Goal-4 Through Culturo-Techno-Contextual-Approach in Innovative Steam Education: A Policy Assessment

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Transformative approaches in education are necessary to advance Sustainable Development Goal 4 (SDG-4), especially in STEAM fields (science, technology, engineering, arts, and mathematics). This article explores cutting-edge research projects that leverage STEAM education to help achieve SDG-4 through Culturo-Techno-Contextual-Approaches (CTCA). The study examines how education changes and highlights how crucial multidisciplinary learning is to solving today's global issues. It looks at how STEAM education encourages students' creativity, critical thinking, and problem-solving skills and equips them to participate actively in sustainable development in their environment. Various CTCAs are examined in STEAM education, such as integrating indigenous strategies, maker spaces, immersive technology, project-based learning, and collaborative platforms. By involving students in practical problem-solving, these methods help them develop a thorough awareness of sustainability concerns and motivate them to develop workable solutions actively. The necessity of ongoing policy assessment and improvement of STEAM education programs to guarantee inclusion, accessibility, and relevance for a wide range of learners around the globe is emphasised in the article's conclusion. To prepare a generation of people to face the challenges of a sustainable future, the government should allocate resources to support the expansion of innovative STEAM education.

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Introduction

The nexus of quality education, inclusive and lifelong education and attaining the remaining sixteen United Nations Sustainable Development Goals (UN SDGs) is highly binding. Ending poverty, hunger, unemployment, climate change issues, gender inequality, unsustainable water management, energy supply challenge, poor economic growth, poor industrialisation, poor human settlements, poor consumption and production patterns, poor use of the terrestrial, aquatic and arboreal environments, pathetic access to justice and pitiable global partnerships hinge primarily on quality, inclusive and lifelong education (SDG-4).

The United Nations Sustainable Development Goals (SDGs) are 17 goals aimed at creating a cleaner planet and a more just global society. The MDGs, formulated in 2000, included eight goals to be achieved by 2015, including eradicating extreme poverty and hunger, achieving universal primary education, promoting gender equality, reducing child mortality, improving maternal health, combating diseases, ensuring environmental sustainability, and developing a global partnership for development (UN, 2015; Gabay, 2015). In 2016, a new plan was launched, increasing the number of goals to seventeen. The SDGs focus on economic growth, social development, and environmental protection, with 169 targets. UNESCO published Education for Sustainable Development Goals: Learning Objectives in 2017, distinguishing cognitive, socio-emotional, and behavioural learning objectives for all SDGs. The focus is on SDG 4, which contains ten (10) specific targets addressing the needs of children, youth, and adults. "Lifelong learning for all" is a crucial element of SDG 4. However, it is essential to avoid viewing the 17 SDGs as fragmented "work packages." Education can act as a powerful "engine" to develop a more cohesive and equal society, and the final goal, SDG 17, emphasises the role of partnerships in achieving the SDGs.

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STEAM education is an innovative, integrated, multidisciplinary construct that engenders the development of 21st-century skills in learners. It is an amalgam of Science, Technology, Engineering, Arts and Mathematics in a holistic paradigm to enhance the learner's critical thinking skills, creativity skills, problem-solving, knowledge construction, digital literacy and many other soft skills expedients for individual employability and entrepreneurship. The learners' learning outcomes in the disjointed science, technology, engineering, arts, and mathematics is deplorably low; how would the learners now cope more efficiently in the integrated STEAM education unless a more comprehensive, indigenous cum modern instructional approach is deployed to enhance optimum instructional interactivity and engagement. Such a novel, the experiential, heuristic, hands-on-mind-on approach is Culturo-Techno-Contextual- Approach, CTCA (Awaah et al., 2022; Ayomide et al., 2022; Gbeleyi et al., 2023).

The current discourse on education policy primarily focuses on benchmarks, indicators, and targets, often called "governance by numbers." International organisations like the European Commission and the Organisation for Economic Co-operation and Development (OECD) have also influenced education policymaking by collecting, monitoring, and publishing statistics supporting pre-defined targets. These reports focus on early school leaving, higher education completion, basic skills, early childhood education, lifelong learning, transition to the labour market, and mobility between countries. However, this approach has faced criticism for potentially placing unhealthy pressure on learners and not providing enough contextual information.

The 2030 Sustainable Development Goal 4 (SDG 4) aims to guarantee integrative and equal quality education and promote opportunities for lifelong learning for all by 2030. The roadmap for achieving the education objective, established in November 2015, advises governments and private sector partners on transforming pledges into action. The International Community sponsors this through partnerships, guidance, institutional strengthening, inspection, and lobbying. The commission will focus on reconsidering the role of education, learning, and knowledge in achieving the SDG 4 targets, aiming to offer equal and equitable education and create opportunities for continuous learning. This article thus reviews the literature on Sustainable Development Goal 4 (SDG 4), innovative STEAM education, the Culturo-Techno-Contextual- Approach (CTCA), the policy issues surrounding fostering sustainable development goal 4 through the culturo-techno-contextual-approach in innovative STEAM education and finally make suggestions for fostered STEAM education through CTCA.

Sustainable Development Goal 4 (SDG 4)

SDG 4 is a crucial aspect of achieving overall sustainable development, with SDG 4 aiming to ensure inclusive and equitable quality education and lifelong learning opportunities for everyone. The goals were formed through consultations with various stakeholders, including civil society, educators, unions, intergovernmental agencies, regional organisations, the private sector, research organisations, and endowments, and the Higher Education Sustainability Initiative (HESI) was established to promote sustainable development research and green campuses.

SDG 4 targets include providing affordable, inclusive, high-quality primary and secondary education for all girls and boys by 2030. It also ensures access to high-quality early childhood education, care, and pre-primary education for all girls and boys. Equality access to cheap, high-quality technological, vocational, and post-secondary schooling, including universities, is also a priority.

Training programs should be expanded and varied to boost the number of young people and adults with the necessary skills for jobs, decent-paying jobs, and entrepreneurship. Emphasis should be placed on developing advanced sensory and non-cognitive/transferable skills, which can be applied across various work environments. Finally, eradicating gender inequalities in education is essential for ensuring equitable access to all types of technical and vocational education for the disadvantaged.

By 2030 (Do et al., 2020), everyone, regardless of gender, age, race, colour, ethnicity, language, religion, political or other beliefs, national or social origin, property, or birth, should have equal access to inclusive, equitable quality education (Koehler, 2016; Mitchell, 2016; Saini et al., 2023). Ethnic minorities, those with impairments, the poor, and naive individuals are vulnerable groups that need extra care and

tailored interventions. As per the declaration, every girl and boy, woman and man, ought to have an equal opportunity to obtain a high-quality education, achieve at comparable levels, and gain similar benefits from education (Koehler, 2016).

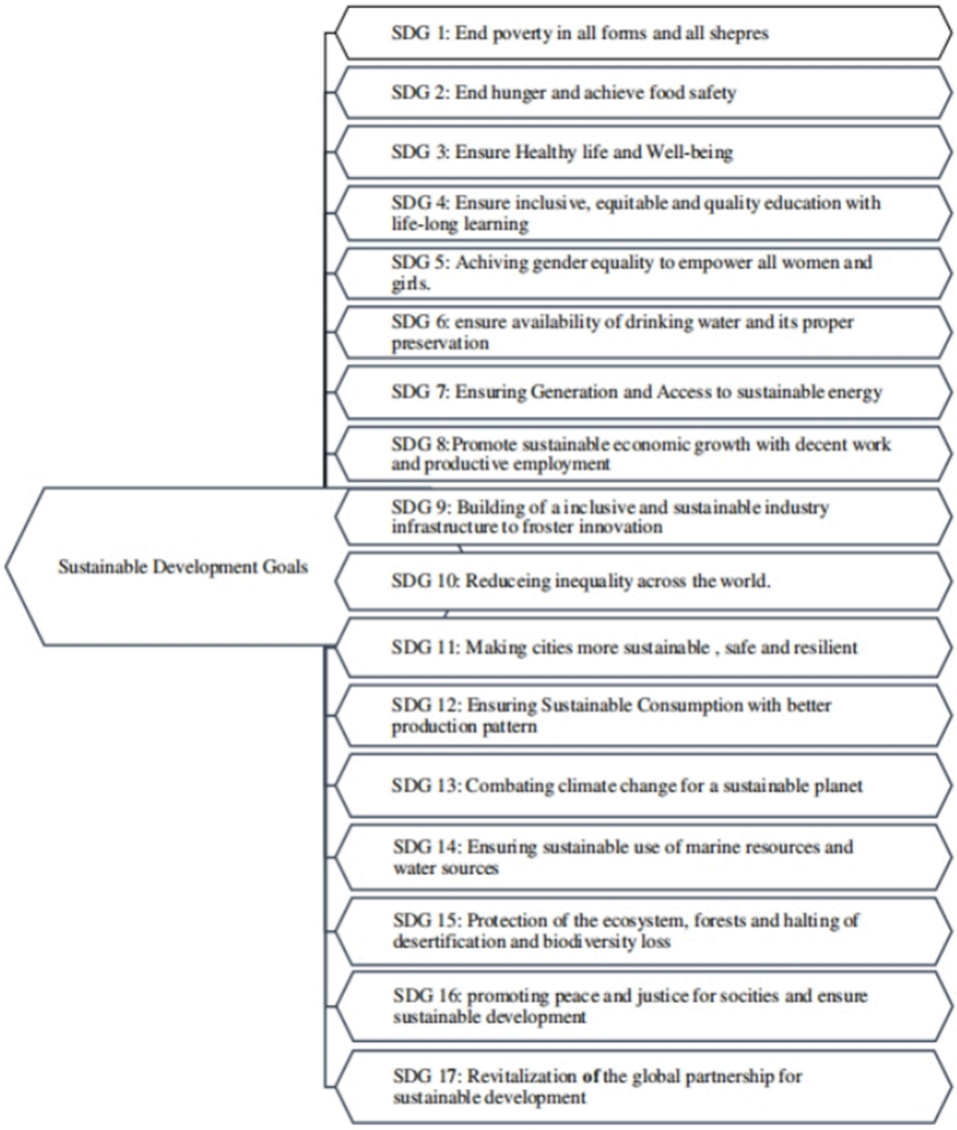

Fig. 1 Sustainable Development Goals (SDG)

Figure 1. Sustainable Development Goals (SDG)

Source Saini et al., 2023

Figure 1 depicts the 17 UN SDGs. The actualisation of the 16 other goals strongly hinges on attaining SDG4, inclusive, equitable and quality education with lifelong learning. Qualitative education will invariably end poverty and hunger, ensure a healthy life and well-being, achieve gender equality, promote a sustainable economy, combat climate change, and revitalise global partnerships.

SDG 4 aims to achieve gender equality, sustainable development, and inclusive education for all by 2030. These goals include achieving reading and numeracy skills for all adolescents and adults, ensuring all learners have the knowledge and experience necessary for sustainable development, and improving educational facilities for children, handicapped, and sex-sensitive students. By 2020, there should be a significant increase in fellowships for tertiary education enrollment for students from poor nations, focusing on fairness,

inclusiveness, and excellence. SDG 4 also aims to influence competent teachers' availability by 2030, mainly through international collaboration for professional development in developing nations. The scarcity and unequal distribution of teachers in poor regions exacerbate the equity gap in schooling.

Additionally, the SDGs focus on health and happiness, gender equality, good work and long-term growth, responsible consumption and manufacturing, and climate change abatement. These goals aim to provide universal access to sexual and reproductive healthcare services, ensure gender equality, decrease the number of young people not in work, schooling, or development, and improve teaching, information campaigns, and infrastructural ability in environmental protection, adaptability, education, and awareness.

Innovative STEAM education

Developed in the 90s, STEM education focuses on educating students in four specific disciplines: science, technology, engineering, and mathematics, using an interdisciplinary and applied approach. The United States has been a leader in promoting STEM careers, but there is a global decline in student interest. The STEM approach aims to develop scientific-technological skills and competencies involving the participation of STEM disciplines (Conradty & Bogner, 2018; Mejias et al., 2021).

The integrative approach is currently widely accepted, but there is debate on integrating the four disciplines. To address this, a proposal was made to include Art as a new discipline in STEAM learning, which promotes interdisciplinarity, facilitates communication, and provides creative strategies and solutions. The European Parliament considers the inclusion of art essential, as it leads to the acquisition of critical competencies and involves divergent thinking, leading to multiple solutions for a single problem (Niu & Cheng, 2022; Niu et al., 2023; Zhan et al., 2023).

STEAM, an acronym for Science, Technology, Engineering, Arts, and Mathematics, was introduced in 2001 by the US National Science Foundation (NSF) to prepare students for STEM careers that often lead to economic stability and upward social mobility. The "A" was added to represent the art/humanities, emphasising the importance of integrating STEM and art into the curriculum.

STEAM projects promote active methodologies, encouraging student participation and knowledge development. These projects enhance attitudes, scientific creativity, and motivation, making students protagonists in discovery. Common teaching strategies include project-based learning, problem-based learning, and collaborative learning. Project-based learning generates a final product through tasks, while problem-based learning addresses new challenges or problems. Both methodologies use cooperative learning, requiring a new classroom structure, time management, evaluation systems, and teacher training. Challenge-based learning guides students' learning by focusing on achievable challenges and enhancing personal skills like teamwork, consensus, negotiation, and leadership (Ozkan & Topsakal, 2021; Zhan et al., 2023; Monkeviciene et al., 2023). Challenge-based learning is widely researched for its application in various Bachelor of Engineering and as an integration between mathematics and physics. The EXPLORIA Project, a new learning approach for university students, requires cooperation between engineering, mathematics, and sciences professors and institutional management (Montés et al., 2022). Teachers must also change their attitude to interconnect subjects and become facilitators of knowledge.

Eshbekovich (2020) proffer the following principles that guide the conduct of STEAM education:

1. The principle of compulsory work. Creating actual product prototypes in the classroom is essential in the STEAM learning context.
2. The principle of cooperation. In the classroom, collaborative activities are organised with the students as teachers, with the students interacting and interacting with each other.
3. The principle of creativity and success. Individual or collective training reveals students' creative abilities.
4. The principle of personality. In the classroom, the teacher helps create the conditions for the individual development of each student. (p. 4)

STEAM education is a learning approach that integrates Science, Technology, Engineering, Arts, and Mathematics. It aims to develop students' critical and creative thinking skills by reimagining real-world problems. Implementing the STEAM approach involves an Engineering Design Process (EDP), which includes problem clarification, program assembly, design planning, prototype construction, testing, optimisation, product analysis, and product presentations (Kartini et al., 2023). The EDP can bridge science and mathematics concepts while considering aesthetics.

Problem-solving is a central activity in STEAM education, supported by learning designs that support the development of computational thinking (CT) dimensions. Decomposition, pattern recognition, abstraction, and algorithm are the CT dimensions that can be embedded in STEAM learning activities (Iskariyana & Ningsih, 2021; Wahyuseptiana et al., 2022).

STEAM has gained attention worldwide for its ability to make it easier to remember, increase cognitive intelligence, and train time management. It also encourages students to think and innovate with art concepts, inspiring them to become creative thinkers in interdisciplinary fields.

The role of STEAM in education is crucial, as it positively influences students' learning process. This concept study aims to help teachers, principals, and administrative and teacher training institutions understand students' needs during learning and develop learning concepts that suit their needs.

STEAM is conceptualised as a transdisciplinary teaching approach, incorporating artistic, creative, and design skills that appeal to a diverse student population. The STEAM education guide consists of two main components:

1. engaging students in solving real-life problems through designing STEAM problem-solving concepts and
2. supporting the improvement of technological capabilities through activities outside of school. STEAM education offers a unique and effective way to develop students' critical and creative thinking skills.

STEAM enhances interdisciplinary knowledge and student project skills through implementing strategies in learning. Research shows that integrating STEAM can improve project competence and learning motivation. The pedagogical STEAM model guides teachers in designing learning activities that suit students' needs, integrating content from various disciplines, and providing fun and flexible teaching strategies. It helps develop problem-solving competencies through inquiry learning. The model is a reference for implementing interdisciplinary curricula and making the learning curriculum enjoyable (Iskariyana & Ningsih, 2021; Kartini et al., 2023; Mariana & Kristanto, 2023).

The Culturo-Techno-Contextual Approach

The Culturo-Techno-Contextual Approach (CTCA) is a teaching method developed by Peter A. Okebukola in 2015 to break down barriers to meaningful science learning. CTCA combines three frameworks: cultural context, technology-mediation, and locational context. It emphasises culture localisation as a basis for understanding human behaviour and promoting learning. The approach is Afrocentric, rooted in ethnophilosophy and technophilosophy. Vygotsky's social constructivism theory provides a strong foundation for CTCA. Students interact with parents and relatives on cultural practices and indigenous knowledge related to the content, watching related videos on YouTube. They learn through interaction and scaffolding with peers, gradually moving from their zone of can-do to a higher Zone of Proximal Development. Ausubel's advanced organiser theory helps students link their ideas with new material or concepts, fostering deep and meaningful learning. When CTCA is being implemented, students are engaged in activities that demand that they:

1. draw on their topic-relevant indigenous (cultural) knowledge;
2. use technology to seek pre-lesson knowledge of the topic to be taught;
3. work in groups to share knowledge gleaned from their socio-cultural interactions and web-based resources;
4. draw on their prior knowledge of the topic when class is in session and

5. relate lesson examples to their local contexts.

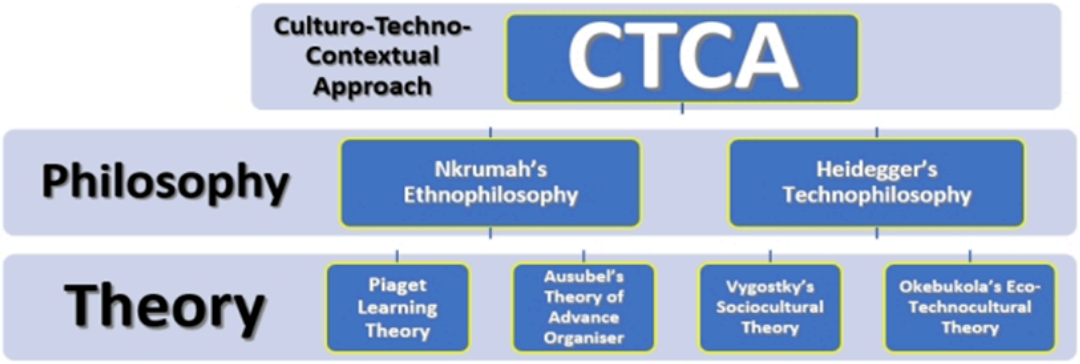

Figure 2. *CTCA Theoretical frameworks.*

Source: Gbeleyi et al. (2022)

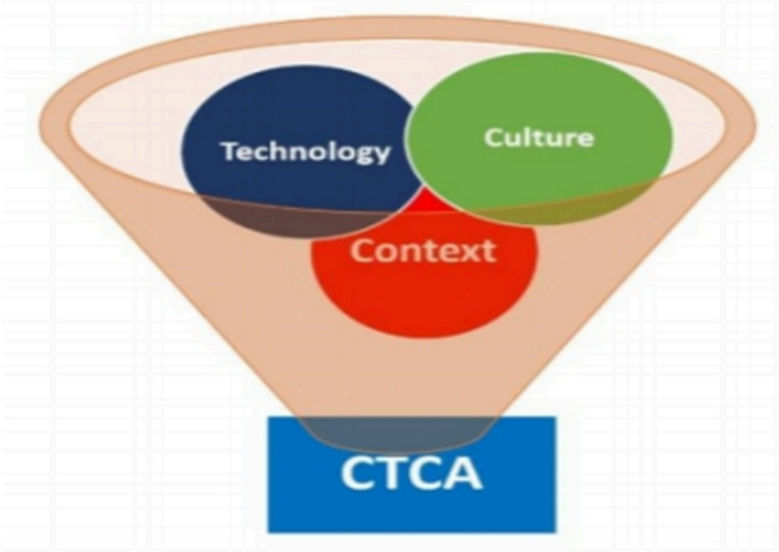

Figure 3. *Tripod of CTCA.*

Source: Ayomide et al. (2022)

From Figures 2 and 3, the CTCA is a teaching method based on culture, technology, and the context or the environment in which teaching and learning occur (Okebukola, 2020; Ayomide et al., 2022). It is anchored on Kwame Nkrumah's ethnophilosophy for culture, Martin Heidegger's techno-philosophy for technology, and Michael Williams' contextualism for the contextual element. In support of the CTCA, Awaah (2020a) argues that a new Afrocentric teaching model that emphasises the use of digital technology in methodology and delivery, as well as the relevance of partnerships in meeting the continent's higher education demands, requires an effective teaching and learning paradigm such as CTCA, especially during the COVID-19 era. Awaah (2020b) refers to the technology component of the CTCA as hinged on the role of technology as a tool that enhances teaching and learning.

The Cognitive-Technological Approach (CTA) is a teaching and learning approach that incorporates the concepts of culture, technology, and context. The CTCA is based on the theories of Piaget, Vygotsky, and Okebukola, who all contributed to the development of the concept. Piaget's cognitive constructivism theory focuses on the acquisition, construction, and use of knowledge, while Vygotsky's cultural-historical theory focuses on the impact of cultural symbols on human mental life. Vygotsky's theory also emphasises the role of cultural signals and symbols in transmitting meaning and social cohesion. Vygotsky's theory also focuses on helping people master complex cognitive skills, such as voluntary attention, categorical perception, conceptual reasoning, and logical memory, which are not fully formed until puberty.

Ausubel's theory of advance organisers connects new learning material with existing notions, similar to the teaching process of CTCA. Implementing CTCA involves informing students about the topic, involving them in group discussions, using practical examples from the school environment, reminding them of the relevance of indigenous knowledge and cultural practices, and sending a lesson summary via SMS or WhatsApp. These theories and philosophies have informed the CTCA's conceptual framework.

CTCA (Cultural, Traditional, and Indigenous Knowledge) is a tool that can help break barriers to meaningful learning in science education. It argues that students' understanding of science is influenced by their cultural, traditional, or indigenous knowledge (Gbeleyi, 2020). By incorporating indigenous knowledge into teaching, traditional barriers can be broken, enhancing students' understanding of scientific ideas. However, many students in the African region find certain concepts challenging to study, leading to academic misconduct.

Indigenous methods are the preferred way to ensure quality teaching, but there is a lack of acceptance of these pedagogies in schools. Black educators face challenges in joining or staying in the teaching profession, and technology is seen as an effective tool for teaching and learning, especially in the African region (Akanbi, 2012; Gbeleyi, 2020).

In the biology classroom, integrating indigenous knowledge can support meaningful learning and cultural sustainability. Indigenous knowledge helps students think about the advocates of life and protect nature and culture from over-exploitation. Biology curriculum developers need to recognise the role of indigenous knowledge and integrate it into development programs for effective teaching and learning. Despite the small sample size, the findings suggest that biology teachers should explore the use of CTCA in improving students' achievement in scientific explanations, particularly in genetics and ecology (Awaah et al., 2020; Awaah et al., 2021a; Awaah et al., 2021b). Other scientific studies include Abdulhadi et al. (2023) and Ademola et al. (2021).

Further, in a survey of 60 Senior Secondary three biology students on the potency of the CTCA on students' achievement and attitude towards mutation and variation in Biology, Adam (2019) found that there was a positive impact of the CTCA as pieces of evidence showed the experimental group students performed better than the control group students on the achievement measure and attitude towards mutation and variation. Abdulhadi et al. (2023) determined the effects of the culturo-techno-contextual-approach (CTCA) on students' understanding of computer science education in a developing economy adopting a pretest-post-test quasi-experimental design found that CTCA raised students' achievement in computer science education.

Promoting Sustainable Development Goal-4 through a Culturo-Techno-Contextual Approach in Innovative STEAM Education: Policy Concerns

Fostering Sustainable Development Goal 4 (SDG-4), which focuses on quality education through a Culturo-Techno-Contextual Approach in Innovative STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education involves addressing various policy issues. Here are some key considerations:

Inclusive Education Policies: Ensure that education policies are inclusive and address the diverse needs of learners from different cultural backgrounds, socioeconomic statuses, and abilities. Develop policies that promote gender equality in STEAM education, encouraging girls and boys to participate equally.

Curriculum Design and Implementation: Develop a culturally responsive curriculum that integrates local contexts, traditions, and knowledge into the STEAM subjects. This aligns with Akanbi's (2012) recommendation that tapping the conventional wisdom of the non-formal education system (especially concerning vocational/technical education) is expedient. This will align the curriculum with technological advancements, fostering innovation and educational relevance.

Teacher Training and Professional Development: Implement policies for teacher training programs that equip educators with the skills to deliver STEAM education in a culturally sensitive manner. Encourage continuous professional development to keep teachers updated on technological and pedagogical advancements.

Access to Technology and Resources: Develop policies to ensure equitable access to technology and learning resources, bridging the digital divide among communities.

Establish initiatives to provide the necessary infrastructure for STEAM education in underserved areas.

Community Engagement: Formulate policies that promote community involvement in educational initiatives, fostering a sense of ownership and cultural relevance. Establish partnerships between schools, communities, and industry to enhance the practical application of STEAM knowledge.

Assessment and Evaluation: Develop assessment methods that consider diverse learning styles and cultural contexts, moving beyond standardised testing. Implement policies that emphasise continuous, formative assessment to support individualised student growth.

Multidisciplinary and Interdisciplinary Approaches: Encourage policies that break down silos between traditional subjects, promoting multidisciplinary and interdisciplinary approaches within STEAM education. Support the integration of arts and humanities to create a holistic learning experience.

Global Collaboration: Develop policies that promote international collaboration in STEAM education, fostering Sustainable Development Goal 17 in international partnership.

Conclusion

The integration of a Culturo-Techno-Contextual (CTC) approach in innovative Science, Technology, Engineering, Arts, and Mathematics (STEAM) education has the potential to significantly contribute to the achievement of Sustainable Development Goal 4 (SDG-4). This approach emphasises the importance of cultural, technological, and contextual considerations in designing educational policies and practices. By fostering a holistic and inclusive learning environment, it addresses the diverse needs of learners and promotes sustainable and equitable development.

The policy assessment indicates that incorporating a CTC approach in STEAM education aligns with the principles of SDG-4, which aims to ensure inclusive and quality education for all. This approach recognises the cultural diversity of learners, embraces technological advancements, and considers local contexts to make education more relevant and effective. Moreover, it fosters creativity, critical thinking, and problem-solving skills, which are essential for addressing the complex challenges associated with sustainable development.

Suggestions

Cultural Sensitivity in Curriculum Design:

- Lecturers should integrate diverse cultural perspectives into the curriculum to make education more inclusive and culturally sensitive.
- Incorporate local knowledge and traditions to make learning materials more relatable for students.
- Technological Integration: ·Invest in technology infrastructure to ensure student and educator access to modern tools and resources. Develop policies that encourage the use of technology in teaching and learning, promoting digital literacy skills.

- Contextual Relevance: Tailor educational content to local contexts, addressing the specific needs and challenges of the community. ·Involve community stakeholders in the educational decision-making process to ensure relevance and sustainability.

Teacher Training and Professional Development:

- Government and Non-Governmental Organizations should provide training programs for educators to equip them with the skills needed to implement the CTC approach effectively.
- Foster a culture of continuous professional development to keep teachers updated on innovative pedagogical practices.

Collaboration and Partnerships:

- Facilitate collaboration between educational institutions, government bodies, NGOs, and private sectors to pool resources and expertise.
- Establish partnerships with cultural organisations, technology companies, and community groups to enhance the learning experience.

Assessment and Evaluation:

- Educational ministries should develop assessment methods that align with the principles of the CTC approach, focusing on a holistic evaluation of students' skills and knowledge. Emphasise formative assessment strategies to provide timely feedback for improvement.

Policy Advocacy:

- Advocate for policies at the national and international levels that support the integration of CTC approaches in STEAM education.
- Highlight the long-term benefits of such policies in achieving SDG-4 and contributing to sustainable development.

By implementing these suggestions, policymakers, educators, and stakeholders can work together to create an educational framework that not only aligns with SDG-4 but also prepares the next generation with the skills and mindset needed for a sustainable and inclusive future.

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