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INTEGRATING AI AND STEM EDUCATION FOR SUSTAINABLE COMMUNITY DEVELOPMENT: A COMPARATIVE STUDY OF URBAN AND RURAL AREAS IN RIVERS STATE, NIGERIA

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ABSTRACT:

This paper investigates the Integrating of AI and STEM Education for Sustainable Community Development: A Comparative Study of Urban and Rural Areas in Rivers State, Nigeria. The introductory part of it focus on the importance of education in attaining sustainable development, it also looked at various forms of education such as; formal, non-formal and informal types of education that foster sustainable community development, it also discussed disparities in accessing quality between Urban and Rural Areas and how AI and STEM can be explored to bridging these gaps. Policy implementation remains a vital means for broadening educational reform in Nigeria. Conceptual aspect of paper provides the theoretical and conceptual underpinnings that guide the study. It identifies key constructs, their interrelationships, and the rationale for their inclusion in the context of education which includes adult education and community development, the work anchored on two theories out of six theories that guided the work, Conceptual Relationships between AI and STEM was discussed, Origin and Purpose, benefits and limitations were also explored. The overview of Sustainable Development Goals (SDGs) as well as the Synergy between SDG 4 & SDG 9 was discussed and how AI and STEM Education can be used in achieving Quality Education in both urban and rural areas, Challenges were identified in educational infrastructure, technology access, and STEM resources, with urban areas holding a significant advantage. It concluded by suggesting the need for ethical considerations for implementing AI and STEM Education in both urban and rural communities in Rivers State.

Keywords: Artificial Intelligence (AI), STEM Education, Sustainable Community Development, Urban and Rural Areas, Comparative Study and Rivers State

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Introduction

The pursuit of sustainable community development has become a global priority, with education playing a pivotal role in achieving this goal. Education whether formal, non-formal or informal is universally recognized as a cornerstone for sustainable development. It equips individuals with the knowledge, skills, and values necessary to address complex societal challenges be it poverty or inequality to climate change and technological disruption. The importance of any form of education to the society (Ebere, Bruce & Raji 2022) can never be over emphasis whether formal, informal or semi-formal because their focus and aim is to inform and educate the citizens. This is one of the main purpose for which adult education programmes was set up for to cater. In the Nigerian context, education plays a pivotal role in achieving the Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure).

The pursuit of sustainable community development has become a global priority, with education playing a pivotal role in achieving this goal. The integration of Artificial Intelligence (AI) and STEM education (Science, Technology, Engineering, and Mathematics) has been recognized as a potential game-changer in fostering innovation, problem-solving, and critical thinking skills necessary for addressing community challenges. Education is essential for human survival. Osuji 2005 in Ossai and Nwalado (2022), to "exist" is more than to 'live' because it means being in the world and at the same time with the world. Thus, one who exists has qualities of transcending, discerning, communicating and participates with others who are existing, whereas one who is merely living does not possess these critical characteristics. Therefore, one whose development of knowledge ceases, has also stopped to exist, he is merely living (Ossai & Nwalado, 2022) and not existing, because, he/she is inactive, as such cannot survive.

Adult education cuts across various aspect of man endeavors and developments, such as, Education for personal development and liberation, Education for skill development and competence, Education for adjustment and sustainability and Education for continuation and awareness, it is the strategy through which adults can uplift themselves socially and economically as to enable them participate fully in the development of their communities. Adult education programmes are by and large offered by adults as a way to earn high school equivalency diploma or to gain knowledge and skill in their chosen profession that will help the adult learner gain knowledge and acquire skills that will enable him/her advance and make reasonable progress in their daily pursuit and also contribute to the development of the society (Ebere, Bruce & Raji 2022), this is crucial as it remain the most important means of economic empowerment, social mobility and personal development of man no matter his/her level and age.

A society is reformed when it has a number of educated and skill men, women and youths that can help in building and repositioning them into the work stream of live. A reformed system is seeing to Nwuche and Enyia (2024), as an educational system that aligned with sustainability principles which can foster lifelong learning, promote environmental stewardship, and catalyze innovation across sectors. "Education is much more than just a corridor through which people walk through a particular destination or personal and national development but basis for achieving sustainable development. (Nwuche & Enyia, 2024) thus: this study with the aims to investigating how integrating of AI and STEM education for sustainable community development in urban and rural areas of Rivers State, identifying challenges, gaps, and development opportunities for improvement.

Disparities in Educational Access and Quality between Urban and Rural Areas

Educational environment whether in Rivers State or in Nigeria as a Nation stark disparities persist between urban and rural educational environments. City education popularly known as urban schools benefit from so many things than the rural or village schools this ranges from better infrastructure, qualified teachers, and access to technological and digital tools and educational resources (Adeyemi, 2020) among others, including quick Government and Non-governmental interventions to their needs and challenges. Despite all these benefits, urban education still faces some challenges like overcrowding, high cost of living and. In contrast, rural schools often suffer from dilapidated/abandon buildings/facilities, limited instructional materials, shortage of trained educators and long period of waiting before Government and Non-Governmental Agencies can respond to their needs or challenges. This is also the reason while external examination performance the urban school does better than their counterparts from rural community. this then call for a question on what next to do in bringing solution to these ugly situations. In recent times, the integration of Artificial Intelligence (AI) and STEM education (Science, Technology, Engineering, and Mathematics) to United Nations Educational, Scientific and Cultural Organization (UNSCO, 2021) has been recognized as a potential game-changer in fostering innovation, problem -solving, and critical thinking skills necessary for addressing community challenges.

The issue of urban-rural divide is further exacerbated by socioeconomic factors, geographic isolation, and policy neglect. "Rural schools frequently struggle with dilapidated buildings, inadequate classroom space, and insufficient learning materials including technological innovations, all of which negatively affect student learning and performance." (Monity & Abam 2024). Rural areas frequently lack reliable internet connectivity, electricity, and other essential infrastructure necessary for AI and STEM education, its often face socio-economic challenges, including poverty and unemployment, which over the years has impacted negatively on educational outcomes. Whereas, the urban areas has better access to quality education, infrastructure, and resources compared to rural areas (OECD, 2020

Exploring How AI and STEM Can Bridge These Gaps

There are gaps not only in learning but also in discrepancies between the Urban and Rural communities that should be bridge and Artificial Intelligence (AI) and STEM (Science, Technology, Engineering, and Mathematics) education innovations offer such transformative potential to bridging these educational and geographical gaps. AI-powered platforms through personalize learning, simulate virtual labs, and provide real-time feedback making quality education accessible even in resource-constrained settings and remote areas such as the rural communities. AI and STEM education can play a crucial role in closing the gap between urban and rural areas by providing access to quality education, promoting innovation, and fostering critical thinking skills creativity, and problem-solving skills essential for community development and economic resilience. (Bers & Portsmore, 2020). Online platforms and AI-powered educational tools can reach remote areas, bridging the geographical divide, that's the reason while Samuel & Salisu (2025) maintained that, AI can address systemic challenges face by rural communities in Rivers State

The use of ULesson and Mavis Computer Apps demonstrate how AI is already enhancing STEM, the science aspect of learning of education in Nigeria thereby making education accessible anytime

and anywhere. “By leveraging AI technologies and STEM into rural educational system, Nigeria can bridge existing gaps in access, equity, and quality, equipping its students with the critical skills needed to compete in a technology-driven global economy.” — (Samuel & Salisu, 2025)

Policy Implications for Rivers State and Broader Nigerian Education Reform

Policy making and implementation has a lot to do in effective integration of AI and STEM Education into Nigeria’s education system demands bold policy reforms in our: curriculum upgrading, teacher capacity-building, digital infrastructure investment, and inclusive access strategies. Rivers State, with its unique intermingle of urban and rural communities, stands to benefit immensely from targeted interventions. This the more reason while, Ukala & Ukala (2024) emphasize the need for strategic policy frameworks that promote AI adoption while safeguarding equity and ethical standards. National initiatives, like the “3 Million Technical Talent (3MTT)” programme and partnerships with technological firms (e.g., Microsoft, MTN Foundation) signal a growing commitment to digital education reform4 because, without robust infrastructural investment, policy guidelines, and ethical frameworks,

Conceptual Review

Conceptual Relationships

AI enhances STEM education by personalizing learning, improving access, and supporting differentiated instruction. STEM education builds community capacity by fostering innovation, problem-solving, and workforce readiness.

AI and STEM Education

Origin and Purpose

The concept of AI in education dates back to the 1960s, but its application in STEM education has gained significant momentum in recent years (Marsha, Sheu, & Gallagher, 2012). AI education is referring to the development of computer systems that can perform tasks that typically require human intelligence in education, such as learning, problem-solving, and making decisions that relates to education matters (Russell & Norvig, (2020) (Russell & Peter 2020). Meaning that, AI can be of help in solving some educational problems;

The full meaning of AI and STEM is:

A – Artificial

I – Intelligent while STEM

S - Science

T - Technology

E - Engineering

M - Mathematics

STEM education has the component of four disciplines in providing a comprehensive and interdisciplinary approach to learning, aims at developing critical thinking, problem-solving, creativity, and innovation skills in learners, preparing them for the demands of the 21st-century workforce and further enhanced to prepare learners for the future of work.

The primary purpose of integrating AI in STEM education is to:

1. Enhance student learning outcomes through personalized and adaptive learning experiences.
2. Foster critical thinking, problem-solving, and creativity.
3. Promote digital literacy and prepare students for the demands of the 21st-century workforce.

Relationship between AI and STEM:
AI enhances STEM education by providing personalized learning experiences, virtual labs, and intelligent tutoring systems. This integration bridges the gap between rural and urban education, ensuring students in rural areas have access to high-quality STEM education. AI-powered tools offer adaptive learning algorithms, real-time feedback, and immersive learning experiences, making STEM subjects more accessible and interesting. AI is an integral part of STEM education, enhancing problem-solving skills, creativity, and innovation. AI can personalize learning experiences, improve student outcomes, and increase access to quality education (Scherer & Holder, 2022), though will some limitations.

Limitations towards AI and STEM effectiveness:
These limitations are: Accessibility and Equity, Infrastructure and Funding and Teacher Shortages among others. The aim of integrating of AI in STEM education, AI and STEM are digital tools that can enhanced teaching/learning process, digital tools to Dokubo, Akpama & Orgwu (2022) entails the use of modern digital teaching and learning technological tools in instructional delivery, with huge benefits as listed by Adeyemi and Adeyemi (2020) provides:

The use of digital learning tools has generated tremendous excitement for all adult, whether urban or rural community, the target adult that will in cooperate learning outcome into reality of traditional teaching/learning experience designed to enhance learning outcomes, promote digital literacy, and equip students with the skills necessary to thrive in a technology-driven world (UNESCO, 2021).

Success Stories of Best Practices
Ghana's STEM Education Initiative: A government-led initiative to promote STEM education in schools, resulting in improved student outcomes and increased interest in STEM fields (Afolabi & Adebayo, 2022).
South Africa's Coding Initiative: South Africa has implemented coding initiatives in schools to promote STEM education and digital literacy (Department of Basic Education, 2020).
In Nigeria, the following programmes were introduced in other to promoting Stem education among students in Nigeria, though, not all the States were captured. These programmes according to Federal Ministry of Education (current n.d) are:

1 **National Policy on Skills Development:** The ministry unveiled this policy in October 2024, focusing on formal and non-formal education
2 **27th National Junior Engineers, Technicians, and Scientists (JETS) Competition**: Held in November 2024, the event aimed to promote STEM education among students.
3 **STEM Camp/Clinic for Female Students**: Organized in December 2024, this program targeted female students in basic and secondary schools in North-East Nigeria.
4 **Environmental Science Education**: The ministry conducted the 18th Annual Globe Project Exhibition, showcasing innovative climate solutions by senior secondary students.
5 **IDEAS Project**: This World Bank-assisted project is enhancing technical and vocational education, with activities including:
6 **Technical Teachers Training**: Implemented in two cohorts, covering all six geo-political zones.
7 **Renovation and Equipping of Technical Colleges**: Ongoing since 2023-2024.

8 **Lagos State's Coding and Robotics Program**: A state-led initiative to introduce coding and robotics in schools, promoting digital literacy and problem-solving skills (Lagos State Government, 2022).
9 **Nigeria's Computer Science Curriculum**: Nigeria has introduced computer science curricula in schools to promote STEM education and digital skills (Federal Ministry of Education, 2020)

Best Practices

1. **Community-Based Approach**: Successful integration of AI and STEM programs requires a community-based approach, where local needs and challenges are prioritized. This ensures that the programs are tailored to meet specific community requirements.
2. **Public-Private Partnerships**: Collaborations between government, private sector, and civil society organizations can enhance the sustainability and scalability of AI and STEM initiatives. For example, the partnership between the Nigerian government and tech companies has facilitated the implementation of AI and STEM programs in schools.
3. **Teacher Training and Capacity Building**: Providing teachers with professional development opportunities is crucial for the effective implementation of AI and STEM programs. Trained teachers can better facilitate learning and inspire students.

Preparing for Future Workforce and Lifelong Learning

AI literacy is becoming an essential skill set for students entering the modern workforce. Integrating AI in education exposes learners to technology-driven problem-solving, ethical considerations, and creative collaboration. Institutions are increasingly prioritizing AI fluency as part of foundational education to equip students with competitive, future-ready skills

Challenges and Ethical Considerations

Urban Areas: faces challenges such as

Overcrowding high cost of living and inadequate infrastructure, however, they often have better access to technology and educational resources over their counter-part in the rural area of Rivers State (Adeyemi, 2020)

Rural Community faces challenges such as

Lack of access to quality education, inadequate infrastructure, and limited exposure to technology (Okojie, 2021), hardly will one find any rural community with adequate and well equipped educational environment including man-power and every other resource associated with good learning environment.

Infrastructure and Resource Challenges: infrastructure and materials for learning and teaching has remain major challenge confronting rural community educational sector, it is either, learners are sitting on the floor, linking, roofs and flooded environment or no teaching staff situations or no school at all. Rural areas frequently lack reliable internet connections, electricity, and other essential infrastructure necessary for AI and STEM education (Ezezika & Nwosu, 2022).

Ethical Concerns:

Data Privacy and Security: AI systems collect and process sensitive student data (academic records, behavioral data, biometric information). Rural areas may have weaker data protection infrastructure, increasing risks of breaches and misuse. Lack of clear informed consent processes can exacerbate privacy violations especially where digital literacy is low. Ensuring encryption, robust cyber security, and compliance with data protection laws is crucial but often challenging in rural settings, due to these challenges integrating AI and STEM education became invisible

Algorithmic Bias and Fairness: AI models trained on non-representative data can perpetuate or worsen biases against marginalized or rural students. Algorithmic decisions (grading, tracking "at-risk" students) may unfairly disadvantage those from rural, low-income, or underrepresented backgrounds. Addressing bias requires diverse, inclusive datasets and routine audits—resources often scarce in rural education systems

Equity and Access (Digital Divide) Rural areas frequently suffer from poor internet connectivity, lack of access to advanced devices, and limited digital literacy, hindering AI adoption, this digital divide risks widening educational inequalities as urban students gain more AI-driven personalized learning benefits, AI systems often assume always-online, high-resource environments, making them less effective or accessible in rural contexts, Investment in infrastructure, affordable technology, and offline-capable AI applications is needed to bridge this gap.

Accountability and Transparency: AI "black-box" decision-making limits understanding of how educational decisions are derived, In rural schools with less technical support, transparency is even more critical but often lacking, Without clear accountability frameworks, errors or biased outcomes can go unchallenged, harming students' academic tragectories.

on Human Agency and Teacher-Student Relationship: Over-reliance on AI risks diminishing teachers' roles, critical thinking, and autonomy of learners, In rural communities, where teacher-student relationships are often closer due to community ties, AI replacing or reducing personal interaction may have outsized negative effects, AI should augment rather than replace human educators, preserving cultural and social dynamics essential in rural education.

Cultural and Contextual Relevance: AI tools developed without rural cultural, linguistic, and contextual input may not align with local learning needs or values, Lack of localization risks disengagement or misalignment with rural educational goals.

Synthesis for Rural Education Context: Digital Infrastructure Gaps and Resource and **Scarcity amplify inequities if AI is not thoughtfully implemented:** Data Privacy Risks are more acute where cyber security expertise and regulations are weaker, Algorithmic Bias that does not reflect rural realities reinforces systemic marginalization, Transparency and accountability mechanisms must be simplified and community-inclusive must be effective in rural schools and Preservation of Human Agency and Cultural Contexts is critical to maintain meaningful learning in rural settings.

The Future of AI in Education: The future promises even deeper integration of AI with immersive technologies like augmented reality (AR) and virtual reality (VR), enabling interactive and experiential learning at scale. AI will foster smart schools tailored to individual student preferences, enhance multilingual communication, and support lifelong, adaptable learning pathways for diverse populations across the globe

Education: Education whether formal, non-formal or informal is universally recognized as a cornerstone for sustainable development. It equips individuals with the knowledge, skills, and values necessary to address complex societal challenges be it poverty or inequality to climate change and technological disruption. The importance of any form of education to the society to Ebere, Bruce and Raji (2022) can never be over emphasis whether formal, informal or semi-formal because, their focus and aim is to inform and educate the citizens based on issues that confront the common man, better his/herself and the society in he/she belong. The main goal of any educational

system is to provide or develop a balanced individual capable of surviving in his or her environment and contribute meaningfully towards the survival of that society to which they belong (its development. (Mozella & moyirade 2024).

Urban Community

Urban communities are densely populated areas with advanced infrastructure, diverse economic activities, and greater access to services such as education, healthcare, and technology. Wordu (2021) describes urban communities as "cohesive groups of people held together by shared territory, ideas, work, and skills," often benefiting from concentrated development efforts.

Rural Community: A rural community refers to a geographically isolated area characterized by low population density, limited infrastructure, and a predominantly agrarian economy. In Nigeria, rural communities often lack access to quality education, healthcare, and technological resources. Egbe, Enyi and John (2021) emphasizes that rural areas in Nigeria are often neglected in development planning, despite housing over 70% of the population. Programmes and Practices for Rural Transformation (with Nigerian context) includes:

1. Literacy enhancement and functional education targeting rural populations.
2. Vocational and skills training aligned with local economic activities.
3. Community health education, agriculture techniques, and environmental conservation.
4. Active involvement of government, NGOs, faith-based organizations (like Adventist Women's Ministries), and community associations.

Rural development

A community is said to development, if, its meets its day to need and can also access information, managed and utilized both its human and material resources effectively and efficiently, **Anaeto,** Francis and Chudi (2021) defines rural development as "a process of increasing the level of living of rural population, measured by food and nutrition level, health, education, housing, recreation and security"., meaning that, rural development has to do with the total wellbeing of individuals in a giving geographical environment or society.

Sustainability

It is ability to control and manage the environment in a manner that is beneficial to all the actors or players in a more conducive form without effecting future generations. It's also refers to the capacity to maintain ecological, economic, and social systems over time without compromising the needs of future generations. Onyenechere, Emmanuella and Chinenye (2022) defines environmental sustainability as "meeting the resource and services needs of current and future generations without compromising the health of the ecosystems that provide them". Adebayo (2021) links sustainability to the balance of economic growth, environmental protection, and social equity within the Nigerian context. Sustainability is unwavering standard in living of a particular region or society over a period of time that attracts and spurs external interest and investors for both economic and infrastruction co-operation or relationship.

Community

A community has to do with one mind set of individuals with same purpose, ideas, needs, challenges, belief, values and of unique interest found in a particular region or containing as "an entity comprising groups and individuals living physically close to each other in a specified

location and sharing common worldviews" Nwangwu (2002) notes that communities are held together by shared territory, ideas, and social practices. it's also mean to be identified as a group of people living in a defined geographical area who share common interests, values, and social ties. Amadei, (2015) known as conceptualizes community.

Development

Defining development is in respect growth or improvement in a particular aspect of life, which may in terms of social, economic, political, environmental, human capacity building and entertainment. It has multidimensional process, as it involves improvements in economic, social, political, and environmental conditions to enhance the quality of life. Gboyega (2003) defines development as "all attempts to improve the conditions of human existence in all ramifications" development in Nigeria to (Lawal & Oluwatoyin (2021) must address poverty, inequality, and infrastructure deficits to be meaningful.

Community Development

Community development is all about people and their ability in making their life better as Cavaye defined it in Ebere and Amachree (2025) as a holistic approach whereby local people can not only create more jobs, income and infrastructure, but also help their community become fundamentally better able to manage change. Community development is a participatory process where community members collectively identify needs, mobilize resources, and implement solutions to improve their living conditions. Wordu, (2021) views it as a movement, method, and programme aimed at improving the lives of individuals and their communities. Ramsey-Soroghaye (2021) understands it as "a process where community members come together to take collective action and generate solutions to common problems"

Characteristics of Community Development: a programme or project can be identified as one only if its focus on collective action and community empowerment, utilizes local resources, leadership, and democratic participation and then aimed at enhancing living standards and socio-economic wellbeing. Community development objectives is mainly to Foster sustainable socio-economic advancement

Challenges in adult education and community development are:

1. Lack of relevant curriculum tailored to local needs.
2. Insufficient understanding of adult education concepts among stakeholders.
3. Limited research facilities and qualified facilitators.
4. Inadequate budgeting and funding for programmes.
5. Low awareness and participation in programme planning and implementation.

Sustainable Development Goals (SDGs): Overview

The SDGs, adopted by the United Nations in 2015, are a universal blueprint to end poverty, protect the planet, and ensure prosperity for all by 2030. Among the 17 goals, SDG 4 (Quality Education) and SDG 9 (Industry, Innovation, and Infrastructure) are pivotal for transforming communities through knowledge, technology, and inclusive development

The Role of SDG 4 in achieving Quality Education

Definition

SDG 4 aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030. It encompasses early childhood education, technical and vocational training, higher education, and adult learning.

Philosophy

The philosophical underpinning of SDG 4 is rooted in **Human Capital Theory**, which posits that investment in education enhances individual productivity and national development (Ogolo, Gloria; Amadi, Ethel ; Nwaoburu, Lucky, 2024). Education is viewed as a transformative tool for empowerment, equity, and sustainability.

The aims of SDG 4 is to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" by 2030. It encompasses early childhood education, technical and vocational training, higher education, and adult learning. It's The philosophical underpinning of it is rooted in Human Capital premise, meaning that investment in education enhances individual productivity and national development (Ogolo, Gloria; Amadi, Ethel; Nwaoburu, Lucky, 2024). Transformative process for empowerment, justice, and sustainability can only be possible through education. its targets are: Equal access to affordable technical, vocational, and tertiary education, promote knowledge and skills for sustainable development, global citizenship, and cultural diversity and Increase youth and adult skills for employment and entrepreneurship.

SDG 9: focuses on Industry, Innovation, and Infrastructure

Definition**:** SDG 9 seeks to "build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation". It emphasizes technological advancement, industrial diversification, and equitable access to ICT. The philosophy behind SDG 9 is grounded in Technological Determinism and Innovation Systems Theory, which argue that technological progress drives economic transformation and social change (UN Nigeria, 2025; SDGs.gov.ng, 2025)4 and it is targeted to achieve the following: Expand access to ICT and affordable internet in developing countries, develop sustainable infrastructure for economic development and to enhance scientific research and innovation capacity.

Implications of AI and STEM Education for Sustainable Development Goal 4 (SDG 4)

Sustainable Development Goal 4 (SDG 4) aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". The integration of AI into STEM education in Rivers State, Nigeria, has profound implications for achieving this goal.

Key Implications:

a) **Enhanced Access to Quality Education**: AI-driven virtual labs can provide rural students with quality science experiences, bridging the gap with urban schools (SDG 4.1).
b) **Future-Ready Workforce**: AI integration in technical and vocational education can equip students with high-demand skills like data analytics and robotics, essential for the modern economy (SDG 4.3)
c) **Inclusive Education**: AI translation tools can make STEM content more accessible to non-English speakers, promoting inclusivity and reducing disparities (SDG 4.5).

d) **Sustainable Development**: AI-enabled STEM projects can empower communities to address local challenges, such as environmental monitoring and oil-spill management (SDG 4.7)

Current Initiatives as reported by EY (Ernst & Young (2024)) are:
1, EY (Ernst & Young (2024)) Organization is working with TeachAI to support educators in teaching with and about AI, while also collaborating with data.org to provide capacity-building workshops on generative AI skills. These efforts aim to promote responsible AI adoption and bridge the digital divide
2, The integration of AI into STEM education in Rivers State carries profound implications for Quality Education: SDG 4 Target AI & STEM Implication 4.1 (Primary/Secondary Education) AI-driven virtual labs provide rural students with quality science experiences previously reserved for elite urban schools.
3, 4.3 (Technical/Vocational) AI helps create "Future-Ready" workers by teaching high-demand skills like data analytics and robotics, essential for the modern Rivers State economy.
4, 4.5 (Eliminate Disparities) AI translation tools can convert STEM content into local dialects (e.g., Ikwerre, Kalabari), making technical education more inclusive for non-English speakers.
5,4.7 (Education for Sustainable Dev) AI-enabled STEM projects allow communities to solve local problems, such as using AI sensors to monitor oil-spill impacts in the Niger Delta.
Other implications include:

The integration of AI and STEM education has significant implications for achieving Sustainable Development Goal 4 (SDG 4) - Quality Education to Nedungadi, Tang, & Raman (2024) are as follows:

1) **Democratization of Knowledge**: AI can serve as a virtual tutor, providing high-quality STEM instruction in rural areas with limited access to specialized teachers. Offline AI models can operate without constant high-speed internet, bridging the gap in educational resources.
2) **Personalized Learning Paths**: AI algorithms can identify individual learning needs and adjust curricula accordingly, promoting lifelong learning and technical literacy among community members, such as farmers and traders (SDG 4.7).
3) **Bridging the Gender Gap**: AI-driven STEM initiatives can reduce gender disparities in technical fields by providing safe, home-based learning environments for girls and women in rural communities.
4) **Skill Alignment with Local Economy**: STEM education focused on community development enables learners to apply skills to real-world issues, such as water purification and sustainable fishing, fulfilling the SDG mandate for relevant employment skills (SDG 4.4).
5) These points highlight the potential of AI and STEM education to enhance quality education, promote inclusivity, and support sustainable community development in Rivers State, Nigeria.

AI as a Catalyst for SDG 4

It addresses teacher shortages by offering intelligent tutoring systems and adaptive learning platforms (Arruda & Arruda 2024). AI can personalize learning, automate assessments, and support inclusive education, especially in underserved rural areas.
Sustainable community development focuses on the combination of economic, social, and ecological sustainability. Adult education plays an essential role in this process by promoting skills related to entrepreneurship, environmental stewardship, and community leadership. This holistic approach ensures that communities are resilient and capable of achieving long-term sustainability goals. Studies have shown that, adult education fosters community resilience, enabling individuals to address local issues related to poverty, unemployment, and environmental degradation (Mulenga, 2022). Adult learners in such contexts are empowered to engage in sustainable practices that contribute to the overall well-being of their communities.
Sustainable community development put together environmental, economic, and social sustainability into community planning and action, ensuring long-term resilience and equity. National Open University of Nigeria (2021) emphasizes that sustainable community development aligns with the Sustainable Development Goals (SDGs) and promotes inclusive, equitable, and participatory practices. Wordu (2021) advocates for a new concept of community development is that which includes sustainability in agriculture, education, health, and infrastructure

Integrating AI and STEM education to the urban and rural community (ies) will give both the children, youths and adults in enhancing their rural occupation and also give them the privilege of meeting world standard of learning, thereby bridging the gap that denies them access to learning thereby making them measurable with their counter-parts that are in a more conducive/technological learning environment, and as a result become more resourceful in meeting their need and excel in their academic performance.

AI supports SDG 4.4 and 4.7 by equipping learners with digital and sustainability-related skills.

STEM Education as a Driver of SDG 9

STEM fosters innovation, critical thinking, and problem-solving—skills essential for industrial growth and infrastructure development.
Integrating STEM in rural education can bridge the urban-rural divide in technological literacy and economic opportunity (Adeshina & Aina 2023).

Synergy Between SDG 4 & SDG 9

Quality education (SDG 4) fuels innovation (SDG 9), while infrastructure (SDG 9) enables access to education (SDG 4).AI and STEM education serve as cross-cutting tools that reinforce both goals, especially in community development contexts.

Theoretical Foundations that guided the work are:

Education has evolved over the years, and various theories and models have been developed to explain the complex interactions between learners, instructors and technology. Distance education

is a complex and multifaceted field that requires a deep understanding of the theories and models that underpin it. These theories are: The Transactional Distance Theory, Diffusion Innovation theory, Andragogy theory, Self-Directed Learning Theory, Community of Inquiry Model, Social Constructivist theory, this study anchors on two theories namely, Technological determinism theory and Andragogy theories. Technological determinism theory posits that technology drives societal changes and develops faster. It was propounded by Thorstein Veblen in 1898 and later developed by other scholars. This theory was used to understand the impact of technology on society and development (Bimber, 2020). and Andrangogy refers to the art and science of helping adults learn was propounded by Malcolm Knowles (1980), andragogy. Knowles posited that adults bring a wealth of experience to the learning process and are self-directed learners. that focuses on learning principles that focuses on solving immediate problem, upgrade and meeting desired needs etc. due to the fact that, are just a few examples of the many theories and models that can inform learning practices for both the adults, youth and children which support the integrating AI and STEM for effective learning outcome that will bring about desire needs in urban and rural communities in Rivers State.

Comparative Study of Urban and Rural Areas in Rivers State

A comparative analysis of urban and rural areas in Rivers State reveals stark disparities in educational infrastructure, technology access, and STEM resources, with urban areas holding a significant advantage. Rural areas struggle with inadequate infrastructure, limited tech access, and poor digital literacy among learners and educators (Oladipo, Olalekan & Adebayo, 2022). These disparities result in noticeable differences in learning outcomes, with urban areas often achieving better results due to stricter curriculum adherence (Adeshina & Aina, 2023).

The integration of AI in rural education raises concerns about data privacy, algorithmic biases, and equitable access. To address these issues, the government must prioritize policy implementation, infrastructure development, and teacher training (UNESCO, 2021). Neglect of non-formal education programs, corruption, and lack of collaboration with private sectors have contributed to these disparities (National Open University of Nigeria, 2021). Its therefore, call for urgent and proactive action through adequate investment, monitory and supervision of projects in addition to welfare package for the operators, administrators and educators/facilitators of this sector in other to achieve sustainable community development

Summary,

AI and STEM Education are importance in education as it creates personalized, inclusive, and efficient learning environments in a situation where teaching and learning is challenged, today, it is AI and STEM, who knows what the next technology would be, that's one the reason while empowering educators and preparing students for a future enriched by the present intelligent technologies become necessary in addition to updating and upgrading oneself with current knowledge and skills. AI and STEM when thoughtfully embraced and ethically managed, can drive transformative educational outcomes towards the sustainability of community developmental efforts in Rivers State and the Nation as well.

Conclusion

The integration of AI in STEM education has the potential to drive sustainable community development in Rivers State, Nigeria. However, addressing the challenges and disparities in access to technology, digital literacy, and STEM education resources is crucial. By implementing targeted solutions, including infrastructure development digital literacy programs, teacher training, and

community engagement, we can promote equitable access to quality AI and STEM education that will take care of learner's education need despite location, age, social responsibilities and individual differences that will foster sustainable community development in Rivers State.

Adult education and community development are inseparable pillars for socio-economic transformation, especially in rural Nigeria, and that, investing in adult education leads directly to empowered individuals who contribute meaningfully to community growth. Sustainable development relies on inclusive, participatory, and locally-driven processes supported by effective adult and non-formal education will make a great difference for effective integration of AI and STEM Education for Sustainable Community Development in Urban and Rural Communities in Rivers State.

Recommendations:

1. Prioritize investment in rural digital infrastructure and devices.
2. Develop offline or low-bandwidth AI educational tools tailored for rural environments.
3. Establish and equip adult education centres accessible to rural populations.
4. Create awareness using local media on the benefits and roles of adult education.
5. Encourage collaboration among government agencies, NGOs, philanthropic organizations, and community groups.
6. Adopt a bottom-up approach ensuring community ownership and sustainable implementation.
7. Prioritize funding, research, monitoring, and the continuous professional development of facilitators.
8. Create transparent, easy-to-understand AI systems and foster digital literacy among rural educators and students.
9. Policy and Practice: Policymakers and practitioners should prioritize the development of AI and STEM education infrastructure in rural areas, ensuring equal access to quality education.
10. Teacher Training: Teachers should be trained to effectively integrate AI and STEM education into their practice, promoting innovative and critical thinking skills.
11. Community Engagement: Communities should be engaged in the development and implementation of AI and STEM education initiatives, ensuring relevance and effectiveness.

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