

STEM AND ENTREPRENEURIAL SKILL DEVELOPMENT IN NIGERIA: CHALLENGES AND FUTURE DIRECTIONS

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Abstract

This paper examines the potential role of Science, Technology, Engineering, and Mathematics (STEM) education and entrepreneurial skill development on the sustainable development of Nigerian economy. STEM education integrates multiple disciplines and plays a critical role in fostering innovation, problem-solving, and critical thinking skills. Entrepreneurial skill development, on the other hand, nurtures creativity, risk-taking, adaptability, and resourcefulness, which are essential for economic growth and job creation. However, Nigeria faces several challenges in leveraging the potential of STEM and entrepreneurial skill development for national development. These challenges include inadequate infrastructure, limited access to quality education, lack of funding, cultural barriers, and a mismatch between educational curricula and industry needs. To address these challenges and pave the way for a prosperous future, a multi-faceted approach is recommended. This includes policy reforms, investment in infrastructure, teacher training and capacity building, research and development support, entrepreneurship promotion, and fostering collaboration between educational institutions, industry stakeholders, and policymakers. By implementing these recommendations, Nigeria can unlock the full potential of STEM and entrepreneurial skill development, driving economic growth, job creation, and overall national development.

Keywords: *Economic Growth, Entrepreneurial Skills, National Development, Nigeria, STEM Education*

Introduction

Science, Technology, Engineering, and Mathematics (STEM) is an interdisciplinary approach that integrates the fields of science, technology, engineering, and mathematics. It plays a crucial role in driving innovation, fostering economic growth, and addressing societal challenges such as STEM education equips individuals with the necessary entrepreneurial skills such as critical thinking, problem-solving, creativity, and innovation to thrive in a rapidly evolving and constantly changing world.

Entrepreneurial skills encompass a range of abilities and traits such as creativity, risk-taking, adaptability, resourcefulness, to list but a few. These entrepreneurial skills are essential for individuals to identify opportunities, launch new ventures, and contribute to economic development. Entrepreneurship serves as a catalyst for job creation, wealth generation, and the

overall growth of a nation's economy (Kumar, et al., 2019; Otache, 2019a; Hassan, et al., 2020; Pugh & Adkins, 2020) Science, Technology Engineering and Mathematics (STEM) education in Nigeria has experienced numerous setbacks despite the government's efforts to promote it. STEM programme in Nigeria is underfunded and lack the infrastructure necessary to make them impactful (Amie-Ogan 2025). For instance, Adeoye (2019) lamented that the absence of laboratories and modern equipment in secondary schools hampers practical STEM education, leaving students to rely mostly on theoretical or abstract knowledge (Adeoye, 2019). This situation is even worse in rural areas where there is often no access to basic science tools and ICT facilities (Ajayi & Aina, 2021).

Moreover, enrollment rates in STEM disciplines remain low. For instance, Aina (2020) reported that the total number of students pursuing STEM courses in Nigerian universities is disproportionately smaller than those in non-STEM fields, partly due to the perception that STEM subjects are more difficult and less rewarding compared to fields such as business or law. The challenges faced by Nigeria in achieving national development through STEM and entrepreneurial skills development sparks several charges in harnessing the potential of STEM and entrepreneurial skill development for national development. These challenges may include inadequate infrastructure, limited access to quality education, lack of funding, cultural barriers, and a mismatch between educational curricula and industry needs. Overcoming these challenges is crucial to unlock the full potential of STEM and entrepreneurship in driving Nigeria's economic growth and development.

Meaning and Goal of STEM

The concept of STEM and its interdisciplinary nature integrates the principles and methodologies of science, technology, engineering, and mathematics to foster holistic learning experiences. STEM encourages students to apply knowledge from multiple disciplines to solve real-world problems. By nurturing skills such as critical thinking, collaboration, and innovation, STEM education prepares individuals for the demands of a technology-driven and knowledge-based economy.

The integration of STEM education in fostering critical thinking, problem-solving, and innovation STEM education places emphasis on experiential learning or learning-by-doing such as inquiry-based learning, hands-on activities, and project-based approaches. This practical-based approach cultivates critical thinking skills, problem-solving abilities, and a deep understanding of scientific principles. Through practical application, students develop innovative solutions and gain the confidence to address complex challenges.

The goals and objectives of STEM education, includes promoting scientific literacy, encouraging technological innovation, and developing a skilled workforce. STEM education aims to enhance scientific literacy among students, equipping them with the knowledge and skills necessary to engage with scientific concepts and principles. It also nurtures technological innovation by fostering creativity, design thinking, and the ability to leverage technology for problem-solving. Additionally, STEM education addresses the need for a skilled workforce by preparing students for diverse career paths in science, technology, engineering, and mathematics.

Entrepreneurial Skill Development

Entrepreneurial skills encompass a set of capabilities that enable individuals to identify opportunities, take calculated risks, innovate, and create value (Rosado-Cubero, 2022). These skills seem to be vital for economic growth as they drive the creation of new businesses, job

opportunities, and the development of innovative products and services. Entrepreneurial skill development, on the other hand, is essential for fostering a culture of entrepreneurship, supporting small and medium enterprises, and nurturing a vibrant entrepreneurial ecosystem.

Key components of entrepreneurial skill include creativity, risk-taking, adaptability, and resourcefulness. Entrepreneurial skill development involves nurturing various competencies. Creativity enables individuals to generate innovative ideas and solutions. Risk-taking involves a calculated assessment of opportunities and potential challenges, allowing entrepreneurs to make informed decisions. Adaptability enables entrepreneurs to adjust their strategies and approaches in response to changing market conditions. Resourcefulness empowers entrepreneurs to leverage available resources effectively, maximizing their chances of success (Powell & Baker, 2011).

Entrepreneurship and Economic Development

Entrepreneurship plays an essential role in Nigeria's economic landscape, with small and medium-sized enterprises (SMEs) contributing over 48% to the national GDP (National Bureau of Statistics, 2021). However, the integration of entrepreneurship education into STEM education programmes has not been fully realized. Programmes like YouWin! and N-Power were created to support entrepreneurship startups and venture creation but they primarily focus on generic entrepreneurship without adequately addressing technology-based businesses (Okeke & Eze, 2022). This lack of focus on STEM-related enterprises implied that young entrepreneurs are often ill-equipped with requisite entrepreneurial skills to develop technology-driven solutions, even though such solutions are crucial for the country's growth in a digital age.

Entrepreneurial Skill Development in Nigeria

Analysis of the current status of entrepreneurial skill development programmes and initiatives in Nigeria shows that Nigeria has made efforts to promote entrepreneurial skill development through various programmes and initiatives (Nkechi 2012). Examples include the Tony Elumelu Foundation Entrepreneurship Programmes which provides training, mentorship, and seed funding to aspiring entrepreneurs. The Bank of Industry's Youth Entrepreneurship Support Programmes offers financial and business management support to young entrepreneurs. However, the reach and impact of these programmes are limited, and there is a need for broader and more comprehensive initiatives (Alderwick; 2021).

Examination of the role of educational institutions, government policies, and industry collaborations in fostering entrepreneurship. Educational institutions play a vital role in nurturing entrepreneurial skills by integrating entrepreneurship education into curricula, providing mentorship programmes and fostering industry linkages. Government policies should focus on creating an enabling environment for entrepreneurship, including favorable regulations, access to finance, and support for innovation. Industry collaborations can provide real-world experiences, mentorship, and opportunities for aspiring entrepreneurs to gain practical skills.

Challenges of Integrating Entrepreneurship into STEM Education in Nigeria

1. *Inadequate Educational Infrastructure:* As previously highlighted, Nigerian schools lack modern facilities and equipment necessary for effective STEM education. Over 60% of secondary schools in Nigeria do not have functional laboratories, and ICT centers are virtually non-existent in most rural areas (Nwabueze 2020).
2. *Teacher Training and Expertise:* The lack of properly trained teachers is a significant barrier to STEM education. Many Nigerian teachers are ill-equipped to teach STEM subjects, primarily due to the absence of continuous professional development programs

(Oyekunle 2019). Additionally, only a small proportion of teachers are trained in entrepreneurial skills, making it difficult to integrate entrepreneurship into STEM teaching (Adedoyin & Olaleye, 2020).

3. *Cultural Barriers and Gender Disparity*: Cultural perceptions about STEM careers, especially among women, continue to pose significant challenges. According to Olabode and Afolabi (2021), there is a prevailing belief that STEM fields are male-dominated, which discourages girls from pursuing careers in science and technology. This cultural bias reduces the potential talent pool that could contribute to STEM-driven entrepreneurial initiatives.
4. *Mismatched Curriculum and Market Needs*: The disconnect between educational curricula and industry requirements is a pervasive issue. Ojo and Amadi (2021) observed that the Current STEM curriculum in Nigeria is too theoretical, often failing to provide students with the practical skills necessary to launch tech-based entrepreneurial startups. This precarious scenario makes it difficult for students to transit from classroom learning to the entrepreneurial world.
5. *Lack of Entrepreneurial Mentorship and Support Systems*: Successful entrepreneurship is often dependent on mentorship and access to a supportive ecosystem. In Nigeria, mentorship programs tailored specifically for STEM entrepreneurs are scarce. For instance, Eze and Udo (2020) highlighted the absence of STEM-focused incubators and hubs that could provide young entrepreneurs with the tools and guidance they need to innovate.

Shaping STEM Skills through AI and Robotics

The rapid advancement of Artificial Intelligence (AI) and robotics technology is reshaping industries, economies, and the future of work across the globe (Rashid 2024). For Nigeria, the integration of these emerging technologies (for example, AI and Robotics) into STEM education presents both opportunities and challenges. As the world shifts towards automation, data-driven decision-making, and intelligent systems, the future of skill development through STEM education will be determined by how well these technologies are embedded in educational curricula, training programs, and entrepreneurship ecosystems. This development and prediction explore how AI and robotics will shape STEM education and skill development in Nigeria over the coming decades.

AI and Robotics: A Game Changer for STEM Education

1. *Personalized and Adaptive Learning*. AI-powered learning platforms can transform the way STEM subjects are taught by creating personalized learning experiences. AI algorithms can assess students' strengths and weaknesses, adjust difficulty levels, and provide real-time feedback tailored to each student's learning pace. This adaptability ensures that students can better understand complex STEM concepts like calculus, physics, or coding, improving overall educational outcomes (Afolabi & Olabode, 2023).

In Nigeria, where large class sizes and teacher shortages are common, AI-driven tools could compensate for these gaps by offering individualized learning pathways. According to Oyeniran and Ogundele (2022), integrating AI-based learning platforms in schools would allow students, especially in underserved areas, to gain access to quality STEM education without relying solely on human teachers.

2. *Virtual Laboratories and Simulations*. Robotics and AI can help overcome the challenge of inadequate infrastructure in Nigerian schools. Virtual laboratories powered by AI offer students hands-on experience with scientific experiments and engineering projects, even in schools without physical lab equipment. With simulations, students can learn programming,

data analysis, and robotics design, all essential skills for the delivery of the 21st century workforce (Ibrahim & Akinola, 2021).

Robotics kits, which allow students to build and program simple robots, can inspire interest in engineering and computer science. AI-driven platforms can further enhance this by simulating real-world engineering problems, encouraging students to develop solutions through trial and error. This practical approach is expected to strengthen students' understanding of complex STEM concepts and foster creativity.

3. *AI-Assisted Research and Innovation.* Artificial Intelligence can revolutionize the way research is conducted in STEM fields by assisting in data analysis, pattern recognition, and hypothesis generation. For Nigerian universities and research institutes, AI-powered tools can boost productivity and efficiency in fields such as healthcare, agriculture, and environmental science. AI's ability to process massive amounts of data quickly enables researchers to uncover insights that were previously inaccessible.

As Nigerian universities adopt AI-driven research tools, students and early-career researchers will be better equipped to develop innovative solutions for local challenges, such as optimizing agricultural yields, managing healthcare systems, and mitigating the effects of climate change (Ojo & Adetola 2023). Furthermore, AI-powered platforms could accelerate the commercialization of STEM research, enabling Nigerian innovators to create market-ready products based on their research findings.

Impact of AI and Robotics on Skill Development in Nigeria

1. *Emerging Skills for the Future Workforce.* The emergence of AI and robotics is changing the nature of work globally, and Nigeria is no exception. While traditional jobs in the fields like manufacturing and administration may become obsolete due to automation, new jobs requiring expertise in AI, machine learning, robotics, and data science are emerging. The World Economic Forum (2021) predicted that by 2030, most of the in-demand skills will be related to STEM fields, particularly in technology-driven sectors such as A.I renewable energy, and biotechnology.

For Nigeria to stay competitive, its workforce must acquire skills in AI development, robotics engineering, programming, data analysis, and automation. Ajibola and Ogunyemi (2022) argued that future STEM education must prioritize these skills to ensure that Nigerian students are prepared for the future job market.

2. *Fostering Entrepreneurial Skills through AI and Robotics.* Science Technology Engineering and Mathematics based entrepreneurship will also be influenced by AI and robotics. As the Nigerian tech ecosystem grows, more startups are expected to focus on AI-driven solutions in industries such as fintech, agritech, health tech, and smart cities. AI will enable entrepreneurs to build intelligent systems that solve local problems at scale. For instance, AI-powered platforms could help entrepreneurs develop personalized financial products for underserved communities or create agricultural drones that improve crop monitoring and management (Oluwole & Adebayo, 2023).

Robotics, on the other hand, has the potential to spawn new entrepreneurial firms and industries. In agriculture, for example, robots can automate tasks such as planting, harvesting, and pest control thereby reducing the need for manual labor and improving productivity. Nigerian entrepreneurs who master these technologies will have opportunities to launch new businesses that drive local economies and create jobs.

3. *Reskilling and Lifelong Learning.* As AI and robotics continue to evolve in a tremendous manner. The Nigerian workforce will need to engage in lifelong learning to keep pace with technological changes. Reskilling programs focusing on AI, robotics, and other emerging technologies will become essential for individuals at all stages of their careers (both in education and profession) According to Nnamdi and Okafor (2023), government initiatives and private sector partnerships must offer continuous training in these fields to help workers to transit from traditional roles to tech-driven industries.

Science Technology Engineering and Mathematics education in secondary schools, universities, and technical colleges will need to focus not only on foundational knowledge but also on developing flexible and adaptive learning pathways that support lifelong learning. Government and educational institutions should collaborate with tech companies to create reskilling programs accessible to a wide audience, particularly those in underserved areas.

Challenges in Adopting AI and Robotics for STEM Education in Nigeria

1. *Infrastructure and Digital Divide.* One of the most significant challenges in integrating AI and robotics into Nigerian STEM education is the lack of digital infrastructure. For instance, Okeke and Eze (2021) argued that many schools still lack access to basic technological tools such as computers and the internet, especially in rural areas. The introduction of AI and robotics would require massive investments in digital infrastructure to ensure equitable access across the country.
2. *Teacher Training and Expertise.* For AI and robotics to become central components of STEM education, Nigerian teachers must be trained in these technologies. However, Eze and Nwankwo (2023) pointed out that most Nigerian teachers lack the technical expertise to teach AI, robotics, or even basic programming skills. There is an urgent need for teacher training programs and interventions that would equip educators with the knowledge and skills required to integrate these technologies into their classrooms.
3. *Cost and Sustainability.* The cost of acquiring AI and robotics tools is high, which may hinder widespread adoption in Nigerian schools, especially public institutions. For instance, Onwughalu and Adeshina (2022) argued that AI systems, robotics kits, and virtual labs require significant financial resources, and without long-term funding strategies, it may be difficult to sustain such initiatives.

Future Directions for STEM Education in Nigeria

1. *Curriculum Reform for AI and Robotics.* To prepare the Nigerian workforce for the future, STEM curricula at all levels of education should be updated to include AI, machine learning, robotics, and data science. This reform should begin at the secondary school level to ensure that students are introduced to these concepts early, thereby fostering interest and skill development in emerging technologies (Oluwaseun & Adeyemi, 2023).
2. *Public-Private Partnerships.* Collaboration between government, educational institutions, and the private sector is essential for the successful integration of AI and robotics into STEM education. Technology companies can provide schools with the necessary tools and resources, while also offering mentorship, internships, and funding for STEM-based entrepreneurship programme (Aderemi & Olaleye, 2022). Public-private partnerships will be crucial in overcoming challenges related to cost and infrastructure.

3. *Establishing AI and Robotics Innovation Hubs.* Innovation hubs focused on AI and robotics should be established in universities and research institutes across Nigeria. These hubs can serve as incubation centers where students and researchers can work on AI and robotics projects that address local challenges. According to Ajayi and Okeke (2023), these hubs can also provide entrepreneurs with the technical resources needed to develop market-ready AI solutions.

Prospects of STEM in Entrepreneurial Skill Development in Nigeria

Exploration of potential strategies and recommendations for overcoming the challenges and advancing STEM and entrepreneurial skill development to overcome the challenges and leverage the potential of STEM and entrepreneurial skill development in Nigeria, several strategies can be adopted. These include improving infrastructure and access to quality education, particularly in rural areas. Strengthening teacher training programs and providing professional development opportunities will enhance the quality of STEM education. Increasing funding for research and development, entrepreneurship programs, and venture capital will spur innovation and support entrepreneurial ventures. Cultivating a culture of entrepreneurship through awareness campaigns, mentorship programs, and industry-academia collaborations will inspire and empower aspiring entrepreneurs. In specific terms, the future direction of STEM education and Entrepreneurial skill development is captured under the following:

1. *Curriculum Overhaul to Integrate Entrepreneurship Education:* Nigerian educational authorities need to revise the current STEM curricula to include entrepreneurship education. According to Bolarinwa and Adeyemi (2021), entrepreneurship should be taught as an integral part of STEM courses to equip students with both technical and business acumen. This approach will help students turn innovative ideas into commercially viable products and services.
2. *Increased Public and Private Sector Collaboration:* The government should foster stronger partnerships with the private sector to create more STEM-based entrepreneurship education programs. Companies can provide mentorship, internships, and funding opportunities for students with innovative ideas (Obi & Osuagwu, 2022). Public-private partnerships would also facilitate the provision of necessary infrastructure and tools for STEM education.
3. *Continuous Professional Development for Teachers:* Professional development programs focusing on STEM teaching methods, technology use, and entrepreneurship are essential. As recommended by Eze (2022), training programs should be provided regularly to ensure that teachers are up-to-date with new teaching strategies and market demands.
4. *Gender Inclusion Initiatives:* To bridge the gender gap in STEM, initiatives targeting girls and young women should be introduced. Scholarship programs, mentorship schemes, and public awareness campaigns can encourage women to pursue STEM careers (Adesina & Ogundele, 2021).
5. *Creation of Innovation Hubs and STEM Incubators:* Establishing innovation hubs in universities will help foster an environment where students can experiment with their ideas and receive guidance from experienced professionals. According to Aluko and Ighalo (2021), such hubs could be instrumental in producing the next generation of tech entrepreneurs in Nigeria.

Conclusion

In conclusion, STEM education and entrepreneurial skill development are vital components for national development in Nigeria. STEM education equips individuals with critical

thinking, problem-solving, and innovation skills, while entrepreneurial skill development nurtures creativity, risk-taking, adaptability, and resourcefulness. However, Nigeria faces significant challenges in harnessing the potential of STEM and entrepreneurial skill development. These challenges include inadequate infrastructure, limited access to quality education, lack of funding, cultural barriers, and a mismatch between educational curricula and industry needs.

The future of STEM education in Nigeria will be significantly shaped by the advancement of AI and robotics technology. These technologies offer exciting opportunities to enhance personalized learning, improve research, and foster innovation. However, challenges such as inadequate infrastructure, a lack of teacher expertise, and funding constraints must be addressed to fully realize the potential of AI and robotics in STEM education. By reforming curricula, investing in digital infrastructure, and fostering public-private partnerships, Nigeria can position itself to develop a highly skilled workforce capable of thriving in an AI-driven economy.

To address these challenges and pave the way for a prosperous future, it is imperative for Nigeria to prioritize the integration of STEM and entrepreneurial skill development. This can be achieved through a multi-faceted approach involving policymakers, educational institutions, industry stakeholders, and individuals committed to promoting national development. By working collaboratively, the following recommendations can be implemented to advance STEM and entrepreneurial skill development in Nigeria:

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