Strengthening Female Representation in STEM and Promoting Gender Equality for Inclusive and Sustainable Development in Nigeria

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ARTICLE INFO	ABSTRACT
Keywords: *Nigeria,* *Mentoring,* *Sustainable Development,* *STEM Fields,* *Women's Education*	Developing a successful STEM career requires more than luck. Globally, a substantial gender disparity persists in the fields of Science, Technology, Engineering, and Mathematics (STEM). Despite progress in women's education, Nigeria still faces underrepresentation of women in STEM. Ensuring equal access to science for women and girls is vital for fostering inclusivity. This review highlights the importance of diversity and equal opportunities in STEM. Key factors for women's success include identifying personal strengths, continuous development, effective mentoring, and networking. Women scientists can drive positive change, champion gender equality, and promote sustainable development. Breaking barriers to STEM education and leadership enhances visibility and opportunities. Creating profiles of women researchers for leadership roles, decision-making, and policy formulation is recommended. Successful women mentors should support younger ones. Mentorship, support networks, and role models are essential in increasing women's participation in STEM, fostering inclusivity, and driving progress toward a gender-balanced scientific community.

1. Introduction

In today's globalized world, Science and Technology (S&T) is pivotal for economic empowerment, quality of life, and national security. It is also considered a crucial means for promoting scientific and technological excellence. STEM (Science, Technology, Engineering, and Mathematics) education emphasizes 21st-century skills by integrating all STEM disciplines at all education levels, from kindergarten to primary (elementary/basic) to secondary (high school) and university level. In the 21st century, it is especially crucial for women and girls to actively pursue scientific and technological development to adapt to the evolving technological advancements in society and the global landscape (Hanum, 2023; Hebebci and Ertuğrul, 2022; Ugras, 2019). Fields in STEM hold immense promise for our country's development and must be noted that we cannot do anything against STEM, but move with it, if not, many people will be left behind (Adesulu-Dahunsi, 2024). While aligning with

the 2030 Sustainable Development Goals (SDGs) of the United Nations (UN), STEM education is seen as a veritable tool that fits into globalisation projects to tackle and combat poverty.

To meet global workforce demands and drive economic growth, industries and organizations depend on integrated STEM education to cultivate a diverse pool of skilled men and women. This ensures an adequate supply of qualified professionals in STEM fields who can contribute meaningfully to a nation's social, technological, and economic advancement (Wang and Degol, 2017). Science plays a pivotal role in achieving the 2030 United Nations SDGs. The significant role the field of S&T plays in the development of any nation cannot be overemphasized. STEM is integral to the advancement of the well-being of any society, some of these roles include shaping modern society, driving innovations, and addressing climate changes, leading to inclusive growth and sustainable development.

There is consistent gender distribution in Nigeria, with women making up just under half of the population. The percentage total population of females in Nigeria according to the World Bank collection of development indicators, was 49.44 % in 2023, and projections for December 31, 2024, estimate the female population at 114,618,283 out of a total population of 232,198,302, representing about 49.35% (World Bank, 2023). Males and females both possess untapped potentials that, when nurtured, can significantly contribute to the world's progress. UNESCO emphasizes the importance of recognizing women's contributions to science to achieve gender equality and foster a better future. However, women's participation in STEM globally has been hindered by the misconception that they lack the capabilities to excel, gender gaps and barriers such as discrimination, harmful stereotypes, biases, social norms, lack of representation and support continue to limit their participation and advancement (UNESCO, 2025). According to UNESCO, no significant increase has been recorded in the number of women participating in STEM fields, as women currently make up only 35% of STEM graduates, this statistic has remained unchanged over the past decade (UNESCO, 2025). This stagnation underpinned the highlighted gender gaps and barriers, which continue to limit women's participation and advancement in these critical fields.

Women remain underrepresented in science, comprising only about 30% of the world's researchers, with even smaller proportions in higher decision-making roles, women are still grossly underrepresented in STEM fields in sub-Saharan Africa (UNESCO, 2017a). In Nigeria and many developing countries in Africa, several causes have resulted in the passive participation of women in STEM, the low enrolment numbers among women in the field of STEM in Africa, can be attributed to some factors, such as family responsibility, educational barriers, workplace challenges, discrimination against women in leadership/decision-making level, traditional beliefs, stereotypes, cultural norms and perceptions that women are not capable of undertaking tough science related courses dampen girls' interest in STEM (Orji, 2024).

In the promotion and development of economy, STEM education takes a leading role in creating a variety of jobs for the world population to be able to confront social issues of poverty, famine, and eradication of diseases. Its knowledge when adequately applied, enables individuals to face and tackle challenges and solve emerging issues in society. STEM fields have considerably transformed communities into more inclusive and equal places and are also critical drivers of innovation and economic growth to build a stronger future. Despite ongoing efforts to inspire and engage women and girls in science, they continue to face significant barriers to entry, full participation, and representation in these fields across many regions. Globally, various organizations have worked for decades to promote gender inclusion in

science. However, women still make up less than 30% of the world's scientists and researchers and remain underrepresented in the field (UNESCO, 2021).

UNESCO highlights a significant global gender imbalance in STEM fields, particularly in sub-Saharan Africa, where women remain underrepresented (UNESCO, 2017a). In Nigeria, a noticeable disparity exists between the number of girls and boys studying STEM subjects at the secondary school level, 35% of girls and 80% of boys, as compared to the ratio at higher education institutions, where we have only 25% female graduates in STEM subjects and 52% males (Musso et al., 2022). Adejimi et al. (2020) examined the relationship between age, gender, and verbal ability in biology subjects among secondary school students in selected schools in Nigeria, and found significant differences in students' performance based on these factors; this indicates that age, gender, and verbal ability are critical predictors of students' participation and engagement in STEM careers or related fields.

Akintoye et al. (2024) reported gender participation of undergraduate students in STEM courses in selected higher institutions of learning in the South-west geopolitical zone of Nigeria, from the result obtained, there is a wide gender gap among the undergraduate students offering STEM courses with the participation of girls less than 43%. However, reports in the literature have shown not up to one-quarter of women in Nigeria constitute STEM graduates in Nigeria's higher institutions, the Nigerian Bureau of Statistics (NBS) and the Financial Institutions Training Centre highlighted that approximately 22% of STEM graduates in Nigeria are women and 29% of women are employed in STEM workforce, with 52.2% overall labour force participation rate among Nigerian, this underscores broader gender disparities beyond STEM fields (UNCTAD, 2019), the statistics indicate that there are underrepresentation in the STEM-related enrolment in Nigeria higher institution and workforce.

In February 2024Nigeria's Honourable Minister of Innovation, Science, and Technology, Chief Uche Nnaji, expressed concern over the underrepresentation of girls and women in STEM courses and careers. In his remarks during the 2024 International Day for Women and Girls in Science, themed "Women and Girls in Science Leadership - a New Era for Sustainability," he described the situation in Nigeria as 'worrisome,' stressing that the country has yet to achieve gender equality in STEM (Punch online, 2024). In his speech, the Minister emphasized the importance of harnessing the transformative power of S & T for Nigeria's national development, stating, "every voice, regardless of gender, must be heard and valued." He assured girls aspiring to careers in science that their curiosity, intellect, and passion are important, adding that "they are not just scientists of tomorrow, but scientists of today." He also encouraged women who are already trailblazing in science to recognize the importance of supporting and uplifting others as they advance and admonished them for breaking down barriers, and challenging stereotypes, thereby creating success pathways for all.

Sustainable Development Goals 4 and 5 recognize the importance of advancing gender parity in the attainment of global goals. Recently, the African Union established its International Centre for Girls and Women Education with its headquarters in Burkina Faso, to provide guidance for member States on integrating gender perspectives into their programs and the implementation of the Continental Education Strategy for Africa 2016-2025 which provides detailed information on how African Governments can bridge the gender gap. After several important steps taken by policymakers and relevant stakeholders in the education sector to improve female participation in the STEM fields, there are still numerous challenges encountered in Nigeria, such as poorly trained teachers, insufficient learning aids, poverty, and inadequate school funding across all levels (Luise, 2023). To overcome these challenges, a multi-faceted approach is required. Such an approach includes employing laboratory assistants for teaching staff, optimum utilisation of resources, organizing workshops for teacher

development, and adopting simplified language for better understanding. These strategies are essential for creating an environment where instructors can be apprised with up-to-date knowledge in the subjects they are teaching and students can learn effectively as well as derive maximum benefits from the teaching experience. This review seeks to explore the critical question: How can mentorship, support networks, and leadership opportunities, enhance women's participation and strengthen female representation in STEM fields in Nigeria? By examining existing works of literature, the review aims to discuss the roles of STEM fields and the need for gender equity, also identifying key enablers and barriers to women's involvement in STEM, and propose strategies to foster gender inclusivity, female visibility, professional growth, and sustainable development through increased and active female participation in science and technology in Nigeria.

1.1   Roles of STEM Fields and the Need for Gender Equity

STEM research plays a key role in the advancement of education in Nigeria. STEM fields are characterized by critical thinking, analytical, and problem-solving skills which are necessary to function adequately in the workforce and tackle societal challenges (Famunyam, 2019). STEM field education is capable of motivating students to practice by using integrated skills they have acquired to solve problems in their community, and by so doing, they become useful for themselves and the society at large.

STEM fields develop and create innovators, inventors, and logical thinkers who become capable of using technology and so doing growth and developments are recorded (Wai et al., 2020). It significantly fosters innovation, which has led to new product development, and improvement in services, leading to the development of new products and improvements in services, which in turn create job opportunities (Akcan et al., 2023). Promoting research and innovation in science education has played a pivotal role in driving its transformation. Furthermore, the integration of STEM in all educational sectors will enhance students participation in class activities and also provide access to the latest scientific information and discoveries. STEM fields create a sustainable environment, improve agricultural productivity, food security, and development of smart cities, thereby making the world a better place (Akcan et al., 2023).

Okafor (2019) described that women continue to be underrepresented in leadership positions within STEM due to various constraints they face, some of these challenges include the perception of STEM as a difficult field, societal beliefs that STEM is primarily for males, cultural norms in African societies, fear, personal choice, and lack of interest all of which significantly influence women's participation in STEM fields. However, several women have achieved remarkable milestones in STEM, even within Africa. For instance, Professor Tebello Nyokong from South Africa was awarded the Africa-Arab States 2009 L'Oréal-UNESCO Award for Women in Science for her groundbreaking research into photodynamic therapy, which explores using light for cancer treatment and environmental remediation. Dorothy K. Gordon is a Ghanaian technology advocate and development expert. She was the founding Director-General of the Ghana-India Kofi Annan Centre of Excellence in ICT (AITI-KACE) and now serves on its advisory council. Additionally, she is a board member of the Linux Professional Institute. With over 25 years of experience in technology and development, Gordon previously served as a Senior Deputy Resident Representative at the United Nations Development Programme (UNDP, 2015; Gordon, 2016a,b, 2020). She has been instrumental in advancing policy and training programs on open-source technologies through her role as a council member of the Free Software and Open Source Foundation for Africa (FOSSFA). In 2013, she was recognized as one of Africa's Most Powerful Women in Technology (ALM, 2013). Additionally, Grace Alele-Williams was the first Nigerian woman to earn a doctorate in

mathematics education and later became the first female Vice-Chancellor of the University of Benin. These examples demonstrate that, with the right motivation and opportunities, women are fully capable of excelling and competing favorably in STEM fields.

1.2   Challenges Affecting Female Participation in STEM Fields in Nigeria

Reports have shown no substantial differences in average IQ between sexes (Irwing and Lynn, 2006; Halpern and Wai, 2020). Research consistently indicates that while minor variations may exist in specific cognitive abilities, such as females tending to excel in verbal tasks and males in spatial tasks, these differences do not confer a general intelligence advantage to either sex (Irwing and Lynn, 2006). Both genders can develop new skills and abilities with practice and experience (Pascual-Leone et al., 2005). Currently, there are no scientific pieces of evidence to support the claim and general belief of the misconception that men have better brains than women, though there are some differences in the structure and function of each gender's brain, this does not relate to that male gender having a better brain female brain is wired to multitask and by this, they have much busier brain compared with the male counterparts i.e. in problem-solving, women tend to harness several areas of the brain (Goldman 2017). Differences in cognitive abilities between genders are often linked to socialisation, educational opportunities, and environmental influences (Engelhardt and Church, 2020). Women and girls have encountered a lot of obstacles which range from institutional to societal to economic and cultural factors, these have greatly impeded their involvement in S&T fields (Musa et al., 2023).

Badaki (2019) attributed the underrepresentation of Nigerian women in the area of infectious disease research to male dominance in senior roles that are well influenced as a result of religious and cultural fundamentalism. This lack of female leadership in research impacts the prioritisation of clinical research agendas, often neglecting diseases and health issues affecting women. Similarly, Opara (2015) emphasized individual and social factors, particularly societal expectations of women, as significant contributors to this disparity, the author ascribed these to traditional cultural norms, discriminatory stereotypes, and gender biases within the education system that favor men's education over women's. As a potential solution, provision of effective resources to support teaching and learning were recommended.

In January 2025, Omoya et al. reported the challenges faced by PhD researchers in African countries, including South Africa, Kenya, Ethiopia, Uganda, and Nigeria, with a focus on the role of gender in the likelihood of completing a PhD. The findings revealed that women PhD students often face greater obstacles, including pervasive gender biases in both social and professional spheres, which hinder their ability to achieve academic goals. Women were also found to be less likely than men to complete their doctoral studies, partly due to cultural expectations and responsibilities. Married women or those with children often juggle household management and caregiving duties alongside their studies. In many African societies, where family responsibilities are traditionally prioritized over career aspirations, women may experience additional guilt or societal pressure, further reducing the time they can dedicate to research. Female participation in STEM fields in Nigeria faces numerous challenges.

Some of the challenges affecting participation of female gender in STEM fields in Nigeria are discussed below:

Cultural norms: STEM fields are often culturally framed as "masculine," which discourages women from pursuing careers in these areas. This stereotype is reinforced by societal expectations, educational curricula, and workplace cultures that prioritize male participation in S&T (Master & Meltzoff, 2020). The cultural norms and barriers that men are superior to

women in terms of the use of their God given brain and cognitive skills should be abolished. The brain makeup of both genders is not superior to each other (Pascual-Leone et al. 2005). Also, peer norms and lack of fit with personal goals make girls move away from STEM courses.

Masculine stereotypes about STEM: There is the traditional belief that is common among Nigerian parents except for a few ones that STEM fields are more apt for men, as women are always advised to pursue careers in non-STEM fields perceived as more feminine (Musso et al., 2022). Often, The notion that women are less capable in these areas has persisted and has discouraged total participation by females (Dicke et al., 2019).

Family expectations and early marriages: In some cultures in Nigeria, especially among the Northerners, parents of young girls are easily persuaded and willing to give their daughters' hands in marriage to a mature man, who probably is a polygamist. A typical Hausa man prioritizes early marriage and childbearing over higher education for girls, limiting their opportunities to pursue STEM careers (Perlman et al., 2018). Many examples have been seen of girls less than 14 years of age being married off without prosecuting the parents that gave their consent in the marriage and the old man that the girl child is betrothed to, who is as old as her fathers, this is stereotypically a case of child abuse(s) prevalent in many villages and communities among the Hausa ethnic groups.

Discrimination: The bias and discrimination against women in S&T and the misconception that formal education is for only the male gender is one of the major challenges affecting female folk in the pursuit of STEM careers (Ebere, 2020). In 2024, the sitting Speaker of Niger State House of Assembly, Honorable Abdulmalik Sarkindaji proposed a bill to sponsor the marriage of 100 young girls in his constituency (Mariga Local Government of Niger State) as part of his constituency empowerment project, where he has reportedly pledged to pay the dowries on behalf of the bridegrooms, procured all necessary materials needed for the mass marriage ceremony and slated the marriage ceremony on the 24th May 2024 at the marriage registry, Mariga LGA, Minna, Niger State, this development elicited reactions from the public why the young girls should be enrolled in school after losing their parents to the banditry (*Boko Haram*) in the Northern part of the country than marrying them off to their fate, his wedding action and plan were halted through the intervention of the Senior Special Assistant to President of Nigeria on Community Engagement Mr. Abiodun Essiet and the former Minister of Women Affairs Mrs Uju Kennedy-Ohanenye. During interrogation, he claimed his action was born out of the community traditional and religious leaders request, who have contacted him to marry off the young girls whose ages were not disclosed (Online newspaper- Daily Post and Vanguard online). This gender stereotype can be hazardous if not curbed and will have negative consequences on the economy of Nigeria.

Perception of STEM as a tough field: Studying and working in STEM has traditionally been portrayed as a domain for men. The perception of STEM as a tough field can be attributed to the rigor and complexity of these fields. Also, these fields require abstract thinking and the capacity to apply theoretical knowledge to practical difficulties (Winterhalter, 2014), while many females think it is not achievable, but can, through supportive educational environments, effective teaching methods, and mentorships.

Unequal access to education: Quality education plays a crucial role in determining future opportunities in S & T. In many rural areas in Nigeria, many children do not have access to education, however, many have to trek distances from their villages to be able to attend schools, all these have limited access to quality education and thus affect their foundational knowledge and interest in STEM subjects (Haruna and Liman, 2015, Grace, 2024).

Curriculum and Pedagogy: The STEM curriculum and pedagogy may not be engaging for girls and often spur their disinterest, which sometimes makes the girls prefer non-science-based subjects at the elementary and secondary school level (González-Pérez et al., 2020). Additionally, teaching methods might not be inclusive, often discouraging girls from participating actively in STEM classes (González-Pérez et al., 2020). It should also be noted that many schools lack adequate facilities and resources, such as laboratories and computers, which are essential for effective STEM teaching and learning.

Limited female role models and lack of mentorship programs: Low participation of women in STEM courses, results in a low percentage of women who are found to be breaking the glass ceiling and occupying the higher leadership levels/positions in Nigeria (Ihuoma et al. 2020). The lack of visible female role models in STEM fields can also be seen as a discouragement for young and aspiring girls to pursue careers in STEM fields. There is a lack of mentorship programs, networking opportunities, and professional support systems for women in STEM (ASM, 2024).

Lack of funds: Economic factors such as lack of funds or financial constraints, where the parents do not have the financial power to send their wards to school can also be a challenge affecting female participation in the STEM field as sometimes many parents earn meager salary, so therefore, boys education are often prioritized over girls (Abolle-Okoyeagu et al., 2024). Also non-availability of scholarship support and financial aid opportunities from the government to encourage girls to pursue their career in STEM courses.

Workplace Discrimination: Systemic discrimination, unconscious bias, and sexual harassment can disrupt women's careers in STEM at an early stage. Women in STEM careers often face discrimination and biases, which can limit their career advancement opportunities (Musso et al., 2022), except a woman receives support from her acquaintances, surviving with the male folk may be a subject of debate.

1.3 Strategies for Enhancing Female Visibility and Active STEM Participation in Nigeria

1.3.1   Increasing Focus on STEM Education

To achieve sustainable technological innovation and address societal challenges, the Government, NGOs, and other relevant stakeholders should recognize the impact of a STEM-enabled society toward a sustainable future, the importance of increased focus on these STEM fields will greatly open the minds of the students and turning them to critical thinkers. STEM fields have aligned with the UN global goals in almost all the 17 SDGs. Improving teaching methods by training teachers of science-based course regularly, and curriculum development which will focus more on STEM and related courses will go a long way in promoting STEM education in Nigeria (Musa, 2023; UNCTAD, 2019; Saka and Onanuga, 2019).

1.3.2   Encouraging Female Enrolment and Participation in Science-Based Subjects

Scholarships specifically designed for women in STEM can alleviate financial barriers and incentivize participation. Promoting gender equality in STEM education is crucial for ensuring equal access to quality education and fostering innovation. Gender equality such as access to education and enrollment in STEM subjects will assist in promoting equal access to quality education. Despite progress in enrollment rates, women remain underrepresented in STEM fields due to persistent socio-cultural barriers, stereotypes, and limited access to resources. Addressing these disparities requires targeted initiatives such as scholarships, mentorship programs, and inclusive policies, the initiatives that will spur the interest of the female gender should also be encouraged by all stakeholders, some of which are; the implementation of

scholarships, and mentorship programs for females to promote gender equity in S&T, as girls are greatly underrepresented in STEM fields (UNESCO, 2020).

1.3.3   Deployment and Use of Technological Tools at All Levels of Education

The integration of technological tools in educational settings is crucial for enhancing science visibility and promoting active STEM participation among students. This is particularly relevant in countries like Nigeria, where access to quality educational resources can be limited. By leveraging digital platforms, virtual laboratories, and educational apps, educators can bridge the resource gap and provide students with engaging, interactive learning experiences. The need for remote learning solutions and the use of digital learning tools across all sectors of education in Nigeria will enhance science visibility and active STEM participation among students. The integration of technological tools such as online platforms, virtual laboratories, and educational apps in the classroom system will contribute to closing the resource gap and enhancing access to quality education (Osetola et al., 2020). Khan Academy and some platforms have been recognized for their role in expanding access to educational resources. Studies on educational apps highlight their effectiveness in personalized learning.

1.3.4   Establishing Mentorship Programs

Mentorship by female professionals, encouraging young girls to pursue STEM careers through hands-on experiences and role models is important in building confidence and providing guidance to the mentees. Mentorship plays a vital role in offering career guidance, boosting confidence, and providing socioemotional support (ASM, 2024). Experienced researchers should have direct communication with the upcoming ones, and also serve as inspiration to the latter. Mentorship programs should be encouraged in all educational sectors, most especially among women. The mentorship will encourage the younger ones to speak up and by then gain immeasurably from the experiences of the senior STEM professionals and through which advice is gained, support is rendered, and guidance to navigate through. Over the years, numerous initiatives have been launched to inspire and support girls and women, fostering gender equality in STEM and implementing diversity policies in research and academic institutions (Moss-Racusin et al., 2012). These efforts include programs encouraging girls to pursue STEM education, promoting female mentorship, and the increasing appointment of female Vice-Chancellors in both public and private universities in Nigeria.

1.3.5   Networking

Programs that connect students with successful women in STEM can counteract stereotypes and inspire career aspirations. Disseminating/networking opportunities in conferences, workshops, and online platforms by experienced women scientists can be an avenue for sharing knowledge (Adeyemo, 2019). Enhancing the representation of women in leadership roles within S&T organisations serves as a strong role model for future generations. Both individuals and organisations must actively support and encourage women to advance into leadership positions by building their confidence. This can be achieved through diversity and inclusion initiatives, as well as mentorship programs. In recent times in Nigeria, many of the virtual platforms facilitated by experienced women researchers are created and available for knowledge sharing and connecting women. Dr. Oluwaseun Iyasere who anchors Women Connect International (WCI) - a virtual social event on WhatsApp for women in academia to connect and interact is a good example. Another example is the WhatsApp group platform 'Ibadan Humboldt Kolleg 2024'; organising yearly cohort programmes called WAAN-I which

is designated to mentoring and grooming young and aspiring academics most especially young females is being anchored by Professor Oluwatoyin Odeku (Faculty of Pharmacy, University of Ibadan, Nigeria).

1.3.6 Upgradation of Existing Infrastructures and Laboratories

Nigeria is increasingly embracing more practical and experiential learning approaches in science education. The basic infrastructures needed for effective transmission of STEM learning across all levels of Nigeria education sector are not generally available or many in dilapidated states, most especially in government-owned schools (Odesomi, 2023). In a recent report in 2020, the Nigerian Education Data Survey (NEDS) investigated that only 30% of government-owned secondary schools had access to functional and well-equipped science laboratories, with less than 20% having reliable internet access and connectivity, these have impeded teaching and practical requirements of STEM subjects, as innovative subjects cannot be taught abstractly (Aina, 2022; Odesomi, 2023). This should be looked into by the Government and well-meaning Nigerians towards active STEM participation.

1.3.7 Awareness and Advocacy

Gender stereotypes significantly impact female interest and self-confidence in STEM subjects from an early age. Studies have shown that girls often underestimate their abilities in mathematics and engineering due to societal perceptions associating these fields with masculine skills (González-Gallego et al., 2025). The increasing awareness of gender disparities in STEM has sparked stronger advocacy for change. International organizations like UNESCO, the Organisation for Women in Science for the Developing World (OWSD), and other gender equality movements have spotlighted the discrimination women encounter in STEM fields. These efforts have prompted institutions to take action to address these challenges. Closing the gender gap in STEM can be accomplished by attracting and retaining more students in STEM programs, as well as improving curriculum and instruction to promote desired outcomes and performance (Jones et al., 2018).

1.3.8 Outreach Campaign

Organizing outreaches, STEM fairs/competitions, and inviting professionals in STEM fields to give career talks to educate and expose students to the exciting possibilities in STEM fields at conferences, and workshops is crucial to enhancing STEM visibility and hereby exposing the students to real-world insights, this will also inspire and empower women to climb the ladder and pursue leadership roles, fostering the confidence that has been instilled in them. Some of the already established successful and functional outreaches established in Nigeria, include; the Nigerian Girl in STEM (NGIS) network, IEEE Outreach by Mistura Muibi-Tijani, Experimento by Siemens Stiftung, Code Nigeria and others that have profoundly exposed students most especially girls to real-world applications of STEM concepts, which has spurred confidence, creativity and critical thinking in the students.

2. Recommendations

UNESCO emphasizes the need for inclusive policies that address structural inequalities and cultural barriers preventing female participation in STEM education (UNESCO, 2017b). It is widely recognized that STEM plays a crucial role in a country's economic, social, and environmental progress, ultimately fostering sustainable development. To increase female participation in STEM careers, Nigeria must foster an inclusive environment where all

stakeholders actively promote gender equity. Early exposure to STEM at all educational levels is crucial for cultivating curiosity, innovation, and problem-solving skills. Integrating STEM courses across curricula will enhance students' competence and interest. The government, educational administrators, and stakeholders should prioritize STEM education by increasing funding, improving infrastructure, training qualified teachers, and addressing societal biases that hinder women's participation. A periodic review of the national curriculum, led by educators, policymakers, and industry experts, will ensure alignment with global STEM standards. Hands-on laboratory experiments, field trips, and real-world projects should be emphasized to enhance practical learning and critical thinking.

It is concerning that women are not included in the development of STEM policies by policymakers (UNCTAD, 2019). To address the lack of funds and facilities required for innovative research in Nigeria, which are often inaccessible to women and girls, there is a need to advocate for scholarships and sponsorships for female scientists based on merit. It is high time that women are actively involved in developing STEM policies in Nigeria. Policies and programs promoting equal participation of women and men in STEM should be implemented. This includes improving access to quality education for girls, providing gender-sensitive teacher training, and offering financial support such as scholarships and grants to reduce economic barriers. Mentorship programs featuring female STEM role models will inspire young girls, while awareness campaigns by media and NGOs will help challenge gender stereotypes. Increasing female representation in leadership roles within S&T sectors will serve as motivation for aspiring women in STEM. Special outreach programs should address the unique challenges faced by girls in rural areas by providing mentorship, career guidance, and socio-cultural support.

Collaboration with the private sector is essential for expanding research opportunities, internships, and funding for women in STEM. Additionally, fostering an entrepreneurial mindset among women through support for STEM startups will drive innovation and economic empowerment. Research funding agencies should implement policies targeting female researchers, while systematic data collection on gender disparities in STEM will inform effective policymaking. Establishing international partnerships for academic exchanges, joint research, and mentorship programs will enhance Nigerian women's global visibility and opportunities. By implementing these strategies, Nigeria can create a more inclusive and equitable STEM ecosystem that empowers women to contribute meaningfully to scientific and technological progress.

To effectively implement the recommendations, Nigeria should adopt a multi-stakeholder approach that tackles systemic challenges, fosters inclusivity, and supports sustainable development in STEM education and career pathways. The following are practical steps for implementation (Business Day, 2022; Aina, 2022; UNCTAD, 2019; Fomunyam, 2019; Ugo and Akpoghol, 2016):

1.   **Promoting Inclusivity in Policy Formulation and Public Awareness Initiatives:** It is essential to actively engage women in the development of STEM-related policies by incorporating female scientists, educators, and policymakers into decision-making bodies. This inclusive approach will facilitate the creation of gender-responsive policies that address the specific challenges faced by women. Furthermore, the implementation of nationwide awareness campaigns, leveraging media platforms, radio jingles, non-governmental organizations (NGOs), and other outreach channels is crucial for challenging prevailing stereotypes about women in STEM fields. These campaigns should also highlight the achievements of female STEM professionals to serve as role models and inspire young girls.

2.   Curriculum Review and Early Exposure to STEM Education: Periodic reviewing of the national curriculum to incorporate STEM subjects across all educational levels should be actively promoted. It is imperative to integrate emerging and transformative technologies such as artificial intelligence (AI), biotechnology, Internet of Things (IoT), machine learning, data science and other evolving technologies into the STEM curriculum at all educational levels. This integration will equip students with the knowledge and skills required to thrive in a rapidly evolving technological landscape and to contribute meaningfully to national development and the global knowledge economy. Moreover, this approach will help close the gap between academic training and industry demands, fostering a more innovative, adaptable, and future-ready STEM workforce. Additionally, integrating practical, hands-on activities such as coding, robotics, and scientific experiments stimulates curiosity and fosters a culture of innovation among students. Likewise, the establishment of STEM clubs within schools will offer valuable extracurricular opportunities for students to engage in STEM-related projects, participate in competitions, and benefit from mentorship programs.

3.   Enhancing Funding and Infrastructure for STEM Advancement: Strengthening STEM education in Nigeria requires substantial investment in both funding and infrastructure. This can be achieved through a combination of government interventions and strategic partnerships with the private sectors. The government should significantly increase budgetary allocations dedicated to STEM education to support the provision of modern teaching and learning facilities, including well-equipped laboratories, computer systems, reliable internet connectivity, and other essential technological tools. Special attention must be given to rural and underserved areas, where infrastructure deficits are most pronounced, to bridge the educational divide and ensure equitable access to quality STEM education (Aina, 2022). In addition, fostering collaborations with private sector entities is crucial for sustaining long-term development in STEM. Such partnerships can facilitate the funding of research projects, the establishment of internship opportunities, and the provision of scholarships, particularly for female students pursuing careers in STEM fields. These initiatives not only enhance capacity building but also promote inclusivity and gender equity in STEM education.

4.   Capacity Building and Professional Development for STEM Educators: Investing in the continuous professional development of teachers is critical to the success of STEM education in Nigeria. One key strategy involves the design and implementation of comprehensive, gender-sensitive teacher training programs. These programs should aim to equip educators with both subject-specific expertise and pedagogical skills necessary to effectively deliver STEM content. Emphasis should be placed on fostering inclusive teaching practices that actively encourage the participation of female students, helping to break down gender stereotypes and promote equal opportunities within STEM fields. Furthermore, enhancing digital literacy among teachers is essential in today's technology-driven educational environment. Educators must be proficient in the use of digital tools and technologies, including interactive software, virtual laboratories, online learning platforms, and multimedia teaching aids. Providing regular training in these areas will not only improve instructional quality but also increase student engagement, foster creativity, and promote the development of critical thinking skills. Ultimately, well-trained and digitally empowered teachers will be better positioned to inspire and prepare students, especially girls for successful careers in STEM.

5.   Addressing Societal Biases through Community Engagement and Mentorship Initiatives: To foster gender equity in STEM education and careers, it is essential to actively challenge and transform deeply rooted societal norms and cultural biases that hinder girls' participation in science and technology-related fields. One effective approach is through structured community engagement programs that involve parents, guardians, traditional leaders, and other key influencers within local communities. Organizing awareness workshops

and sensitization campaigns targeted at these groups can play a pivotal role in shifting perceptions. These programs should focus on educating stakeholders about the critical importance of gender inclusivity in STEM and the long-term socio-economic benefits of supporting girls' education and careers in these disciplines. By highlighting the value of equal opportunities, such engagements can help dismantle stereotypes and create more supportive environments for girls to pursue their interests in STEM. Furthermore, implementing structured mentorship initiatives that connect young girls with accomplished female professionals in STEM is vital. These role models can provide guidance, share their personal experiences, and offer career insights that help build confidence, resilience, and ambition among aspiring female students. Mentorship programs should also include workshops on leadership development, academic planning, and career exploration, ultimately empowering girls to envision and achieve successful futures in STEM-related fields.

6. **Provision of Financial Support through Scholarships and Research Grants:** Reducing economic barriers is a critical step toward enhancing female participation and retention in STEM education and careers. One strategic approach is the establishment of merit-based scholarships and financial aid programs specifically targeted at female students pursuing studies in STEM. These scholarships should be designed to support academically talented and motivated young women, particularly those from underrepresented or economically disadvantaged backgrounds, thereby enabling them to access quality education and complete their academic journeys without financial constraints. In addition to supporting students, it is equally important to promote gender equity within the research ecosystem. Funding agencies and research institutions should be encouraged to implement gender-responsive policies that prioritize or reserve a proportion of grants for female researchers. This includes providing seed funding, research fellowships, and innovation grants tailored to support women-led projects in STEM disciplines. Such initiatives will help bridge the gender gap in scientific research and innovation, empower women to lead groundbreaking studies, and contribute meaningfully to national and global development through their work in STEM.

7. **Promotion of Leadership Opportunities and Support for Women-Led Innovation in STEM:** Advancing gender equity in STEM necessitates intentional strategies to increase the representation of women in leadership positions across STEM sectors. Policy advocacy should prioritize the establishment of institutional frameworks that actively facilitate the inclusion of qualified women in decision-making roles, including departmental heads, directors of research institutes, academic deans, and executive positions within STEM-related organizations. Enhancing the visibility of women in these influential roles is critical for challenging entrenched gender stereotypes and serves as a significant source of inspiration and motivation for emerging female scientists, technologists, and innovators. Simultaneously, it is imperative to cultivate a supportive ecosystem that fosters women's entrepreneurial potential within STEM fields. This can be achieved by providing targeted funding opportunities, comprehensive business development training, and technical support tailored to women-led startups. Such initiatives should include access to innovation hubs, incubation programs, and mentorship networks designed to address the specific challenges encountered by women entrepreneurs. By promoting both leadership and entrepreneurial advancement among women in STEM, Nigeria can leverage its full human capital potential, stimulate inclusive economic growth, and enhance its global competitiveness in science and technology

8. **Fostering International Partnerships to Enhance Global Visibility and Opportunities for Women in STEM:** Establishing robust international collaborations is a vital strategy for advancing the participation and recognition of Nigerian women in STEM on a global scale. Strategic partnerships with international organizations, universities, research institutions, and development agencies can open doors to a wealth of opportunities, including academic exchanges, joint research initiatives, and professional development programs. These

collaborations should aim to facilitate the exchange of knowledge, expertise, and best practices while providing Nigerian female students, researchers, and professionals with access to cutting-edge resources, advanced technologies, and global mentorship networks. Academic exchange programs can enable female students and scholars to study or conduct research abroad, exposing them to diverse scientific perspectives and broadening their academic and professional horizons. Furthermore, joint research projects involving multidisciplinary and cross-border teams will not only strengthen local research capacity but also elevate the international visibility and contributions of Nigerian women in STEM. Mentorship programs with accomplished women in global STEM communities can also serve to build confidence, develop leadership skills, and inspire a new generation of female innovators and scientists. By fostering such international partnerships, Nigeria can accelerate the integration of its women into the global STEM landscape and promote inclusive scientific advancement.

By actively implementing the practical steps outlined, Nigeria has the opportunity to cultivate a more inclusive and dynamic STEM ecosystem that not only empowers women but also strengthens the country's scientific and technological capacities. Creating a supportive environment for women in STEM through policy reform, educational enhancements, community engagement, financial support, and international collaborations can break down the barriers that have historically hindered their full participation. As a result, Nigerian women will be equipped with the tools, resources, and opportunities necessary to make significant contributions to scientific progress and innovation. This empowerment will not only benefit individual women but also have broader societal and economic implications, as increased female participation in STEM fields will lead to more diverse and innovative solutions to the country's pressing challenges. Furthermore, by encouraging the growth of women-led businesses and research initiatives, Nigeria can foster entrepreneurship, job creation, and technological advancement, driving long-term economic growth. Ultimately, by ensuring that women have equal opportunities to excel in STEM, Nigeria can build a more resilient and sustainable future, characterized by a diversified economy and a society that values inclusivity, equity, and the transformative power of education and innovation.

3. Conclusion

Gender equality in STEM should not be an elusive goal, as women should not be sidelined in addressing key STEM issues. Nigeria can unlock the full potential of female participation in the STEM field while amounting to significant contributions to STEM, and driving innovation and progress for the nation. By tackling the challenges hindering female participation in STEM fields in Nigeria, we can foster a more inclusive environment that encourages and supports women in these areas. Scientific and technological advancement can only be achieved through research and innovation, and both genders must be seen giving their contributions to its actualisation, this can only be accomplished by enhancing women's visibility across public and private sectors, thereby creating a sustainable future.

Governments, universities, and funding organizations can work together by offering scholarships and research grants, developing gender equality policies, and establishing or enhancing mentorship programs. This collaboration between academia, industry, and government agencies should be actively encouraged to ensure the successful transfer of scientific knowledge into practical applications. Commitment to fostering diversity, an inclusive environment, and mentorships by all stakeholders will spur the participation of girls in STEM, thus breaking barriers that may impede visibility among females in STEM fields and the attainment of true gender equality. However, there is also an urgent need to develop enabling policies to reduce the gender gap in STEM at all levels of education, increase women

in STEM visibility and active participation, provision of funding and support for research projects and innovation hubs in schools, identify gaps in the policy mix, and implement the national science, technology, and innovation policies related to gender with no prejudice. In conclusion, as efforts continue toward achieving and surpassing the 2030 Sustainable Development Goals, it is imperative to acknowledge that the participation of women and girls in STEM will be instrumental in advancing sustainable development in Nigeria.

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