Navigating STEM: Challenges Faced by Nigerian Female Secondary School Students

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Abstract
The persistent gender disparities in Science, Technology, Engineering, and Mathematics (STEM) fields stand as a significant barrier to realizing the United Nations' Sustainable Development Goals (SDGs), particularly those related to gender equality (SDG5), quality education (SDG4), and decent work in Nigeria. This paper examines the depth and implications of gender imbalances within STEM and underscores the multifaceted benefits of addressing this issue for broader societal progress. Leveraging a qualitative approach through content analysis of 139 secondary school students in Nigeria, we uncover the root causes behind the underrepresentation of women in STEM, using a theoretical framework of social context and social environment to form the basis of our analysis. Our sample was gotten from female secondary school students in both public and private schools in Nigeria. Our findings reveal that family influence play a significant role in the choice of STEM education for the girl child. Therefore, we recommend that encouraging girls' involvement in STEM subjects from the home front, as this is crucial, in dismantling cultural barriers and stereotypes for the girl child. This could be done through intentional role modelling and signposting to careers in STEM. We argue that by eliminating gender disparities in STEM, not only can women be propelled to the forefront of innovation, but can accelerate global efforts to meet the SDGs, fostering a more equitable and prosperous world.

Keywords: Gender, Stem Education, Sustainable Development Goals, Girls in Stem, Nigeria

1. Introduction

The field of STEM which have long been vital to technological advancement and economic growth have historically been dominated by men, leading to significant gender disparities that have been a point of discussion and concern for decades [1]. STEM fields which play an important role in the progression and realisation of the UN SDGs also hold answers to most global challenges, and as the world traverses towards a more sustainable future, its knowledge and associated innovative solutions would be beneficial. Thus, promoting and advocating a global all-inclusive gender participation in STEM fields is imperative for the realisation of the SDGs.

Equal access to STEM is not just a societal essential for development but also the fifth target of UN SDGs with its mission statement, "Achieve gender equality and empower all women and girls" (United Nations, 2015). However, global statistics reveal that women are still underrepresented in STEM fields [2], which interestingly is much worse for third world countries, particularly Nigeria that ranks a lowly Index [3].

Traditionally, societal norms and cultural biases have played a significant role in influencing gender disparities in STEM as a good portion of the society still associate STEM disciplines with men, and this misconception invariably discourages girls from pursuing these careers [4]. In Nigeria, STEM fields are perceived as masculine professions which dates back to historical biases and community customs that discouraged or excluded women from pursuing education and careers in these areas [5]. Degradingly, these societal expectations regularly direct women towards disciplines considered more 'appropriate' for their gender, such as nursing or teaching. This historical challenge set the stage for long-standing gender imbalances in STEM.

A key factor that contributes to gender disparities in STEM is the educational environment in Nigeria [6]. From school age, girls often receive subliminal messages that STEM subjects are for boys, and this prejudice can be observed in various forms, ranging from gendered toys and activities to the representation of scientists and engineers predominantly as males in the media. Studies have shown that these stereotypes play a big role in adversely influencing the interest and curiosity of young girls from pursuing STEM subjects from an early age, a phenomenon known as the "pipeline problem" [7].

In Nigeria, another reason for the poor gender disparity in STEM is religion. Religion plays a significant role in Nigerian society and can influence various dimensions of life, including education [8]. This can be particularly notable in regions with strong religious identities, e.g., northern parts of Nigeria with numerous religious schools which prioritize religious teachings and do not place a strong emphasis on STEM subjects.

Another issue that has aggravated this gender disparity in Nigeria, is the lack of female representation. Due to the low number of women in these fields, young girls have very few models to inspire them to pursue careers in STEM. This lack of visibility inadvertently reinforces the stereotype that STEM is not a field for women and with fewer women in these fields, young girls have fewer role models to inspire them to pursue STEM careers. [9] also argues that this issue is directly worsened by the gender pay gap. Regardless of the comparable requisite educational qualifications, trainings and relevant experiences possessed by women in STEM, their male counterparts earn far more. This situation isn't only

demoralising but ultimately makes it tough for women to attain financial independence and feel motivated in their professions.

Tackling gender disparities in STEM in Nigeria is a complicated challenge that would require a versatile approach in changing societal perceptions, providing support and opportunities for women in STEM fields, and creating an enabling environment enshrined in equality diversity and inclusion. While progress has undoubtedly been achieved thus far, there is still a lot to be done to achieve gender equality in STEM. An in-depth understanding of the effect of gender disparities in STEM is fundamental to fostering inclusivity and leveraging diverse perspectives essential for meeting the SDGs. Understanding the roots and implications of these disparities is crucial for fostering an inclusive and equitable environment in STEM disciplines. Therefore, this study critically analyses and presents the outcomes of a research study carried out to understand the reasons for these gender disparities in Nigeria.

2. Literature Review

The literature review is in two parts. Firstly, we discuss gender stereotypes and Nigerian Education and then we adopt a theoretical framework to help better understand the implications this has on the advancement of STEM education in Nigeria.

2.1 Gender Stereotypes and Nigerian Education

The discourse on students' participation in STEM-related education and how this influences their choice of career is well documented in the literature, and the call to achieving Sustainable Development Goals 4 – which is Quality Education can be useful in addressing this perceived gap [10]. In Nigeria, the girl-child has an already low educational entry and attainment level as fewer girls are seen enrolling in schools than boys [11]. In fact, according to [12], the gender gap widens as girls move up into tertiary education. Interestingly, there are regulations in Nigeria to support equal and free education for males and females, such as Section 18 of the Nigerian Constitution, the Child Rights Act 2003, the Universal Basic Education (UBE) Act 2004, and Article 17 of the African Charter. Despite these great policy initiatives, the level of attainment of girl-child education remains low as majority of the girls drop out before finishing their junior secondary school education.

The literature has tried to explain some of the reasons behind these anomalies and how the policy initiatives have not helped Nigeria achieve SDG4 which can be connected to the achievement of SDG5 which is gender equality. According to [13], "*gender stereotypes are roles or a pattern of behaviour placed on a particular sex by the society, mostly beliefs, illogical ideas and false phrases*". As a result of patriarchy, girls are exposed to more traditional caring roles and kitchen roles, while boys are exposed to more roles that give them the power to dominate [14] . To differentiate between sex and gender, sex is more biological, while gender reflects more of the socially constructed realities of individuals [14] (under review). These constructed realities have implications for the kinds of subjects enrolled in by males and females, educational opportunities, literacy rates, STEM careers, etc. A person groomed as a domesticated career is most likely to choose school subjects that can highlight these attributes, while a person groomed as a provider is more likely to choose subjects that are more analytical in nature [15].

From a theoretical perspective, the Eccles's Expectancy-Value Theory (EVT) (Eccles, 1983, 2009; 2020) [16], can be used for studying the intricate gendered factors contributing to these

perceived disparities as evidenced in the number of enrolled pupils in STEM education which ultimately affects their career choice. This theory suggests that achievement-related choices consist of two categories: expectancy for success and subjective task value. Expectancy of Success refers to expectations by the students and how this can be influenced through childhood and adolescence experiences such as gender stereotypes and socio-cultural factors. Second are the subjective task values, which suggest that due to the different perceived values of enrolling in school and into STEM subjects, the choice for schooling and the choice of subjects will remain subjective. The next section uses a framework to help better understand the factors affecting STEM persistence in Nigeria.

2.2 Theoretical Framework

The theoretical model of factors affecting STEM persistence by [17] see Figure 1 below, is used to demonstrate the interplay between several factors to achieve the desired educational outcomes within a particular country or context. This framework has been used in various contexts such as in the Gulf Cooperation Council (GCC) states [18] to discuss the factors influencing STEM student participation in the region. This study will pay attention to the social context and social environment in Nigeria and how this influences STEM education.
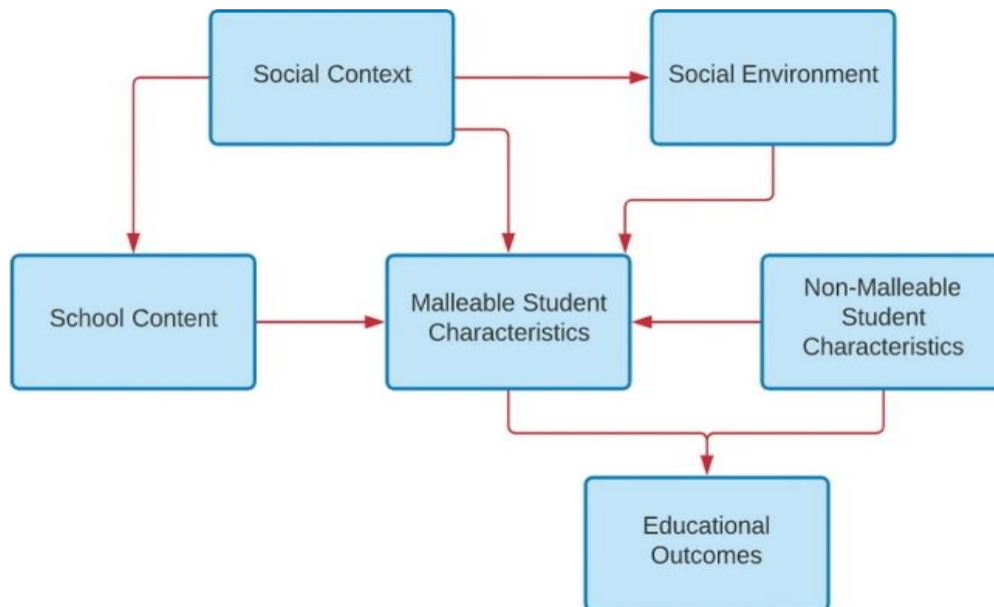

Figure 1. Theoretical model of factors affecting STEM persistence. Source: [17]

2.2.1 Social Context: include the socio-cultural factors that builds up the constructed realities of males and females in Nigeria. In a patriarchal society such as Nigeria, it is expected that a girl should be seen, not heard and therefore positioned to be inferior to boys [19]. These social norms and believes have been culturally transmitted through generations during the process of socialization. Socialization simply means the process by which children and young adults learn from others around them [20], and according to [21], the pattern of socialization available in Africa seems to allow boys more privileges than the girls.

Cultural Stereotypes also shape how STEM subjects and career are perceived. For example, [13] identified occupations such as; Engineering, Medicine, Law, Computer Science, and Skilled trades, as being more befitting for boys in Nigeria while for girls, Nursing, Secretarial

work, and Catering services are more suitable. This invariably means that this stereotypical career choice of girls means an avoidance of science-based courses, particularly mathematics.

2.2.2 Social Environment according to the framework includes role models, mentors, and an influence from family members that could possibly influence the choices of choosing STEM subjects in schools. The mother who is most likely not in a STEM career due to passed on generational stereotypes, is responsible in providing role models for their daughters, while the father's responsibility is demonstrating to their sons what it means to 'be a man' (World Bank Report, 2005). The cultural stereotypes prevalent in Nigeria create an image of 'science is for males' picture in the minds of young people reducing any form of interest from females [13]. As suggested by [10], there is a correlation between interest in a subject choice and what the stereotype is, impacting over what the young child believes to be true or normal. Another area where role modelling influences subject choice is in the visual images used as instructional materials [22]. It is argued [23] that these instructional materials and textbooks plays a key role in forming the motivation for young peoples' career. These factors continue to present a shortage of role models in STEM careers ultimately influences the choice of females choosing STEM subjects and careers.

3. Methodology

The study is aimed at identifying the most important factors hindering girls' participation in STEM education in Nigeria. The study will employ a qualitative method in investigating the perceived barriers hindering the participation of girls in STEM education in Nigeria to identify the most significant barriers. This approach will provide a holistic understanding of the social and environmental factors influencing female engagement in STEM education.

To understand the barrier to STEM education from the viewpoint of students, the simple random probability sampling technique was used to select the research participants from different secondary school in Nigeria. Using this method minimises sampling bias as the viewpoint of both male and female students were collected from different schools across the southern and northern part of Nigeria. The selection criteria were based on the class of students (Junior Secondary School one to Senior Secondary School three) and age range 13-20 years.

A structured questionnaire was administered to collect quantitative data from 130 students on their perception of STEM education barriers. The questionnaire analyses 5 dimensions (interest, parent influence, exposure to STEM, mentorship, role of teachers) consisting of 10 questions. The survey included Likert-scale, multiple choice, and open-ended questions to capture wide perspectives.

Having a spread of sample across the different region in Nigeria was a challenge as this stage of the research, but considering this will be an on-going process, that limitation would be covered in the future. The responses from the questionnaire were first analysed using descriptive statistics such as the frequencies, percentages, means values to summarise the students' perceptions of the barriers to girls' engagement in STEM education. Narrative content analysis was adopted in identifying the predictors of perceived barriers.

A key ethical consideration in data collection was to get informed consent of participants by making clear the study objectives, procedures, risks, and benefits. Measures were

implemented to ensure the confidentiality and anonymity of participants identities and responses.

4. Results and Findings

Demographic Data

Out of the 139 responses received, 89 (64%) were from the female student and 50 (36 %) came from the male students. Student within the age range 10-13 gave the highest response of 47.5 %, while the 41.7% responses came from students with the age range 14-16 and only 10.8% were from students between 17-19 years. We gather insights from students attending both private and public secondary schools to have a broad view of the challenges of STEM students in Nigeria. The response from private secondary school is 75.5 %, which is three times the responses from students in public schools. There was also a geographical spread of the students across five geopolitical zones in Nigeria that completed the survey. The southeast had the highest share of 49.6 %, southern region 27.3 %, western region 18.7 % and Northern Nigeria 4.3 %.
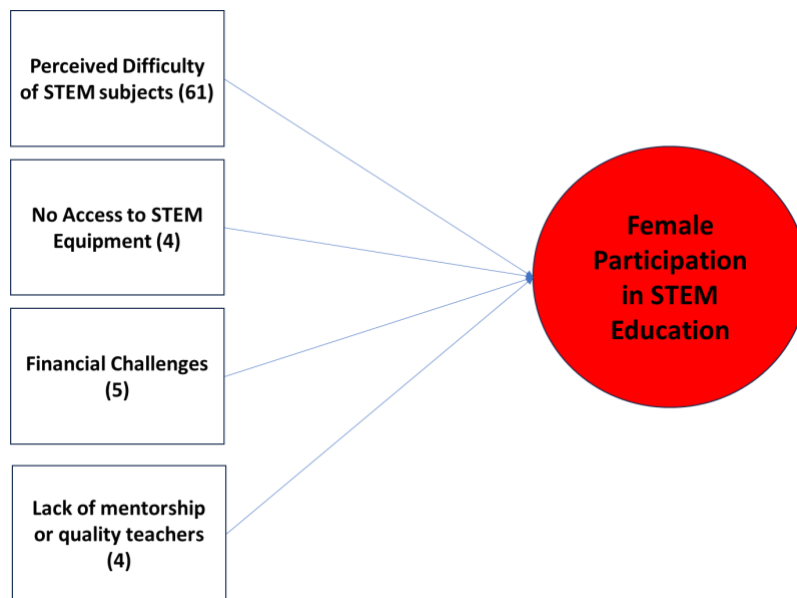

Figure 2. Threat to Female Students' Participation in STEM Education.

The responses of 74 female students to the open question "What would you say is the biggest challenge you face or have faced in pursuing a STEM subject?", suggests the 'perceived difficulty in STEM subjects' with 61 respondents is the most significant threat to their participation in STEM. Other identified themes such as, "No Access to STEM Education", "Financial Challenges", and "Lack of mentorship or quality teachers", were at the average of four responses.

The "perceived difficult" in STEM also emerged as the most significant barrier when the students were asked, "If you had/have any hesitations in choosing a STEM subject, what are they?". It is unclear at this stage of the research, whether the "perceived difficulty" is intrinsically motivated or is something the students' have been made to belief.

Considering that these findings are based on self-reporting by students already in secondary school, these "perceived difficulty" could be connecting to the way STEM subjects are

taught. Despite only four respondents mentioned the lack of teachers and mentors as their challenge, this could be the experiences of other students across the country.

While most of the challenges mentioned by the students appear to be extrinsically motivated, the inherent causes of these challenges are still under investigation. The influence of parent was mentioned by one student who said, "I love science because my parents are engineers". Another student said, "my father won't approve of me going to arts". These two responses show the parent has a strong influence in the career path their children follow. This aligns with the social environmental factors as suggested by the theoretical framework, see section 2.2.2.

The reason the 'perceived difficulty in STEM subjects" appear to be very significant is unclear at this stage of the study but the responses suggest there are underlying factors that may have created such perceptions in the minds of the students.

To understand these "perceived difficulty" we got the viewpoints of the students on, "How do you think STEM education could be improved to attract more students?" Interestingly, "investment in STEM equipment", "STEM campaigns", "Teaching and mentorship" and "funding and accessibility" emerged as the most important themes. These solutions all appear to be external. It appears only external factors can be identified from the viewpoints of the students. The students may not even be aware of any intrinsic bias they may have or have learned from the environment about STEM subject.

The idea that "it is difficult", suggest they may have experience something easy or have been made to believe STEM subjects are difficult.

Table 1. Which STEM field are you currently involved in or interested in?

Gender	Arts	Engineering	Mathematics	Science	Technology
Female	9.0%	4.5%	10.1%	70.8%	5.6%
Male	10.0%	26.0%	20.0%	38.0%	6.0%
Total	9.4%	12.2%	13.7%	59.0%	5.8%

The current engagement of the students in STEM shows the female student are mostly participating in sciences (70.8%), while the percentage share of other STEM areas is relatively low. For the male, their current participation in STEM tend to spread across all areas, even though science with 38.0% is the highest, there was significant participation in engineering and mathematics, at 26.0% and 20.0 % respectively. This result suggests although the female participation in STEM tend to be within certain area while males are exploring and engaging widely in different aspects.

Table 2. Encouragement from teachers or educational institutions

Gender	Not at all Influential	Slightly Influential	Moderately Influential	Highly Influential	Extremely Influential
Female	5.6%	2.2%	10.1%	19.1%	62.9%
Male	8.0%	4.0%	40.0%	24.0%	24.0%
Total	6.5%	2.9%	20.9%	20.9%	48.9%

In Table 2, in comparison with the males, the female participation in STEM extremely depends on the encouragement they get from their teachers and schools. This strongly aligns with the findings of [19] and how the educational system uses instructional materials to re-enforce the STEM is meant for boy's narrative unknowingly.

Table 3. Access to resources (e.g., laboratories, technology, etc.)

Gender	Not at all Influential	Slightly Influential	Moderately Influential	Highly Influential	Extremely Influential
Female	20.2%	11.2%	14.6%	20.2%	33.7%
Male	20.0%	10.0%	34.0%	24.0%	12.0%
Total	20.1%	10.8%	21.6%	21.6%	25.9%

From Table 3, access to STEM resources like laboratories and technology are important in influencing the choice of STEM for both male and female students.

Table 4. Perceived difficulty of the subject

Gender	Not at all Influential	Slightly Influential	Moderately Influential	Highly Influential	Extremely Influential
Female	18.0%	11.2%	22.5%	22.5%	25.8%
Male	18.0%	14.0%	20.0%	22.0%	26.0%
Total	18.0%	12.2%	21.6%	22.3%	25.9%

'Perceived difficult" in STEM appears to be a problem for both genders with about 48% indicating it is highly to extremely influential to their currently STEM studies.

Table 5. Influence from family

Gender	Not at all Influential	Slightly Influential	Moderately Influential	Highly Influential	Extremely Influential
Female	20.2%	6.7%	13.5%	18.0%	41.6%
Male	14.0%	10.0%	22.0%	22.0%	32.0%
Total	18.0%	7.9%	16.5%	19.4%	38.1%

Family influence play a significant role in the choice of STEM education as 41.6% of the female students reported to be extremely influenced by their family. This value was only 32.0 % for the male students. This finding aligns with the influence of cultural stereotypes as enforced from the family unit as indicated in the theoretical framework [19] and how STEM subjects and careers are shaped from the family. The literature suggests that occupations such as; Engineering, Medicine, Law, Computer Science, and Skilled trades, are being shaped as being more befitting for boys than for girls in Nigeria [15] while for girls, Nursing, Secretarial work, and Catering services are more suitable. This invariably means that this stereotypical career choice of girls might mean an avoidance of science-based courses, particularly mathematics.

5. Conclusion and Recommendations for Policy and Practice

As mentioned earlier, the STEM gender disparities in Nigeria are multifaceted and would require a collective effort to address. The future of STEM in Nigeria depends on harnessing the full potential of all genders, which necessitates continued efforts in education, policymaking, religious and cultural change.

Encouraging girls' involvement in STEM subjects is crucial, necessitating prioritized programs to dismantle cultural barriers and stereotypes at all levels of government. Moreso the complex relationship between religion and STEM education in Nigeria requires careful navigation to balance respect for religious beliefs with the promotion of scientific literacy, vital for advancing STEM education in Nigeria especially in the northern regions. Policy changes should encourage organizations to increase women's representation in STEM through measures like gender quotas. Professional networks like the Association of Professional Women Engineers of Nigeria and Nigeria Women in STEM can provide essential support, mentorship, and advocacy for gender equality in STEM. Increased research into gender disparities informs policies, while government initiatives, such as scholarships and mentorship programs, demonstrate commitment to gender equality. However, there is a need for more research and data collection focused on girls in STEM fields in Nigeria, covering enrolment rates, graduation rates, employment statistics, career trajectories, and other factors influencing participation. This study is also limited in uncovering institutional biases that could influence women's enrolment in STEM subjects, this could serve as an area for future research.

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