Gender Disparities in Stem Pathways: Investigating Student Interest in Robotics and Software Development in Secondary Schools in Nsukka

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Abstract
The study examined gender disparities in STEM education pathways, particularly in robotics and software development, across secondary schools in Nsukka. By analyzing institutional data, national competitions, and regional initiatives, it identifies systemic barriers hindering female participation in technology. Key findings revealed that only 22% of Nigeria's engineering and technology graduates are women, with cultural stereotypes, infrastructure gaps, and teaching methods exacerbating these disparities. The University of Nigeria Secondary School, a leading institution with 1,000 students and advanced ICT resources, illustrates both opportunities and challenges in STEM education. While 58.46% of students support programming curriculum integration, 71.07% of schools lack sufficient computing infrastructure, disproportionately impacting girls. The research demonstrates that simulation-based teaching significantly boosts programming interest compared to traditional methods. Initiatives like the Avishay National Robotics Contest and "Project 10,000 Kids" highlight hands-on learning potential but show persistent gender imbalances. Cultural norms framing STEM as male-dominated, alongside economic barriers and workplace inequities, further restrict female engagement. Recommendations propose multi-tiered strategies: gender-inclusive curricula, infrastructure development, and policies promoting flexible work environments and anti-harassment measures. The study stressed the urgency of addressing these gaps to unlock Nigeria's technological capabilities, advocating collaborations among schools, government bodies, and international organizations like UNESCO, which advances the STEM and Gender Advancement (SAGA) framework for progress monitoring. These insights enrich global conversations on equitable STEM education while offering practical guidance for Nigerian policymakers and educators.
Keywords: Robotics, Software Development, STEM, Gender

Introduction

The educational landscape in Nsukka, anchored by the prestigious University of Nigeria, presents a complex picture of STEM participation that reflects broader national challenges. The University of Nigeria, established in 1955 as Nigeria's first indigenous university, has played a pivotal role in STEM education development with its 17 faculties and 102 academic departments offering over 108 undergraduate programs (Jilomes, 2015). However, despite this robust institutional foundation, gender disparities persist across STEM disciplines, particularly in technology-focused areas such as robotics and software development.

Research conducted at the University of Agriculture, Makurdi, which serves as a representative case study for Nigerian higher education institutions, reveals significant gender imbalances where male students consistently outnumber their female counterparts in Mathematics, Computer Science, and Statistics programs. This pattern appears consistent across Nigerian educational institutions, with findings suggesting that societal stereotypes, self-efficacy perceptions, and parental influence significantly shape

career choices, perpetuating the underrepresentation of women in STEM fields. The implications of these disparities extend beyond individual educational outcomes to encompass broader questions of national technological capacity and innovation potential.

Secondary School STEM Infrastructure in Nsukka

The secondary school infrastructure in Nsukka provides a foundation for STEM education, though with varying levels of technological integration. The University of Nigeria Secondary School, established in January 1983, serves as a flagship institution with a student population of 1,000 and a teaching staff of 101 (Edusko, 2025). This co-educational institution offers comprehensive laboratory facilities and standard ICT centers, positioning it as a leader in STEM education delivery within the region. The school's proximity to the University of Nigeria campus provides unique advantages in terms of access to advanced educational resources and academic mentorship opportunities.

However, assessments of ICT usage among secondary schools in the broader Nsukka Education Zone reveal significant challenges in effective technology integration. Research findings indicate that ICT is not effectively utilized in lesson preparation, instructional delivery, individualized learning, and collaborative learning among computer studies teachers and students. This technological gap creates barriers to effective STEM education delivery, particularly in emerging fields like robotics and software development that require hands-on experience with advanced computing systems and programming environments.

Robotics Education Initiatives and Student Engagement

The emergence of robotics education initiatives in Nigeria has created new opportunities for STEM engagement, though participation patterns reveal concerning gender disparities. The Avishkaar National Robotics Contest, Nigeria's maiden edition held in 2024, demonstrated significant student interest in robotics and artificial intelligence applications (ThisDay Newspaper, 2024). Schools such as Heritage Global Academy, Ikorodu, and Graine Royale International School, Ijaiye-Ojokoro, emerged as winners in various categories, showcasing the potential for robotics education to inspire technological innovation among Nigerian students.

The competition's structure, featuring three categories—IRC (Robotics construction), Makeathon (Engineering Innovation), and Gameathon (coding challenges)—across primary, junior, middle, and senior leagues, provides comprehensive pathways for student engagement with robotics technologies. However, detailed analysis of participation demographics would be essential to understand gender representation patterns within these competitive frameworks. The global dimension of these competitions, with winners representing Nigeria at international events in Delhi, India, underscores the importance of ensuring equitable participation across gender lines.

Programming and Software Development Interest

Student interest in programming and software development within Nsukka secondary schools presents a nuanced picture of engagement and barriers. Research conducted in nearby educational zones reveals that 58.46% of secondary school students strongly agree that programming lessons should be included in the curriculum, with an additional 27.68% expressing agreement (FITC, 2023). This substantial interest level suggests significant potential for expanding software development education, provided appropriate infrastructure and pedagogical approaches are implemented.

However, practical implementation faces considerable challenges. The same research indicates that students have limited

background knowledge in programming languages, with only 27.7% of respondents reporting basic knowledge of C++ (FITC, 2023). Furthermore, 71.07% of students indicate that their schools lack adequate facilities and resources, such as computers and network infrastructure, necessary for effective practical programming instruction (Ugwu, 2018). These infrastructure deficits create particular barriers for female students who may already face additional social and cultural obstacles to STEM participation.

Institutional Responses and Gender-Inclusive Initiatives

Educational institutions and organizations within Nigeria have begun implementing targeted initiatives to address gender disparities in STEM education. The Financial Institutions Training Centre (FITC) organized a hybrid program titled 'DigitALL: Innovation and Technology as Enablers for Gender Equality' during the 2023 International Women's Day celebration, advocating for transformative digital and technology-driven education systems that are gender-sensitive and accessible to women and girls (Ibrahim et al, 2023). These institutional responses recognize the critical importance of addressing systemic barriers that limit female participation in technological fields.

The Network of Nigerian Women in STEM (NWiSTEM), in collaboration with organizations such as Siemens Stiftung and the Civil Society Action Coalition on Education for All (CSACEFA), has actively engaged in equipping both boys and girls with STEM skills through train-the-trainers' programs [11]. These initiatives represent important steps toward creating more inclusive educational environments that support diverse participation in robotics and software development education.

University-Level STEM Programs and Gender Dynamics

The University of Nigeria's Department of Computer and Robotics Education provides valuable insights into institutional approaches to STEM gender inclusion. Established as a full-fledged department with robotics option in July 2015, after existing as a sub-department for 23 years, the department currently offers five academic programs that have received full accreditation from the National Universities Commission (Fernández Polcuch, 2016). The department's evolution reflects growing recognition of the importance of science education in addressing national development needs, though specific gender participation data would be essential for comprehensive analysis.

The department's focus on science education provides a critical pathway for developing the next generation of STEM educators who can implement gender-inclusive pedagogical approaches. Research indicates that effective STEM motivation for girls requires encouragement from a young age through increased enrollment in primary, secondary, and vocational education (Ibrahim et al, 2023). University-level science education programs play a crucial role in preparing educators who can implement these early intervention strategies effectively.

Barriers to Female Participation in STEM

Cultural and social barriers represent significant obstacles to female participation in robotics and software development education within Nsukka secondary schools. Research indicates that one of the major challenges affecting female participation in STEM is the perception of these fields as inherently difficult or "tough," leading to indirect discouragement of girls from pursuing these areas (Vanguard Newspaper, 2023). Many girls are socialized to believe that STEM fields are "reserved for boys," while others internalize notions that they should focus on fields considered more traditionally feminine rather than engaging with brain-challenging technological disciplines.

Gender stereotypes in STEM continue to affect productivity and interest levels among women in these fields, creating persistent

barriers to achievement (Ibrahim et al, 2023). UNESCO has consistently promoted awareness of women's participation in STEM and urges countries to break the chains of socio-cultural gender biases and stereotypes that hinder milestone achievements in women's STEM participation. The organization's STEM and Gender Advancement (SAGA) Survey framework measures gender equality in science and engineering, providing tools for tracking progress in addressing these persistent challenges.

Economic and Infrastructure Challenges

Economic factors and infrastructure limitations compound gender-based barriers to STEM participation. Research reveals that women in STEM careers typically do not progress as far as their male counterparts, often publish less research, and receive lower compensation for their contributions (Odo, 2016). These economic realities create disincentives for young women considering STEM career pathways, particularly in fields like robotics and software development that require significant initial investment in education and training.

Infrastructure challenges are particularly acute in secondary schools within the Nsukka Education Zone. Assessment data indicates that 71.07% of schools lack adequate facilities and resources necessary for effective ICT instruction, including sufficient computers and network infrastructure (Odo, 2016). These limitations disproportionately affect female students who may have less access to technology resources outside of school environments, creating cumulative disadvantages in technological literacy development.

Student Interest Patterns and Motivational Factors

Analysis of student interest patterns in robotics and software development reveals complex dynamics influenced by peer groups, educational experiences, and exposure opportunities. Research conducted in secondary schools indicates that 40% of students strongly agree that peer groups encourage learning programming among members, while 19.23% also express agreement (FITC, 2023) However, 35% of students strongly disagree with this statement, suggesting significant variation in peer support networks for technological learning.

The role of hands-on learning experiences appears particularly important for sustaining student interest in robotics and programming. The "Project 10,000 Kids" initiative, which aims to teach 10,000 Nigerian schoolchildren how to build robots, emphasizes the importance of exposing young learners to real-world engineering challenges through LEGO-based robotics projects (). This approach recognizes that creating innovators and problem solvers requires moving beyond traditional academic memorization to engage students in practical, creative technological applications.

Impact of Educational Methodology on Interest

Research examining the effectiveness of different pedagogical approaches reveals significant impacts on student interest and engagement. A quasi-experimental study conducted in Enugu Education Zone found that students taught programming using simulation methods achieved higher interest levels than those taught through traditional approaches (Punch Newspaper, 2024). The study utilized a sample of 225 students from four secondary schools and obtained a reliability coefficient of 0.89, providing robust evidence for the effectiveness of innovative instructional methodologies.

These findings suggest that educational methodology plays a crucial role in developing student interest in programming and robotics, with implications for gender inclusion efforts. Simulation-based approaches may be particularly effective for engaging female students who might otherwise be discouraged by traditional, theoretical presentations of

technological concepts. The research recommends that ministries of education revisit instructional materials and methodologies used in STEM teaching to optimize student engagement across diverse populations.

National Context and International Comparisons

Nigeria's gender disparities in STEM education must be understood within broader national and international contexts. The Minister of Innovation, Science, and Technology, Uche Nnaji, has expressed significant concern over the low representation of women and girls in science-related courses and professions, describing the current situation as worrisome (UNESCO, n.d). National statistics indicate that approximately 22% of STEM graduates in Nigeria are women, while UNESCO reports that only 35% of STEM students in higher education globally are women.

Within sub-Saharan Africa, women account for less than 20% of professionals in engineering and technology-related fields, indicating that Nigeria's challenges are part of broader regional patterns (CSCUK, 2023). However, international initiatives such as the Robotics for Good Youth Challenge, organized under UN auspices, provide opportunities for Nigerian students to engage with global STEM networks and competitions focused on sustainable development goals (Balogun, 2015). These international connections offer potential pathways for expanding local STEM education opportunities while promoting gender inclusion.

Technology Industry Employment Patterns

Analysis of technology industry employment patterns reveals the long-term implications of educational gender disparities. In Nigeria's information and communication technology sector, women represent only about 5% of STEM graduates working in the field, while occupying just 25% of overall technology industry employment and only 5% of leadership positions (Ibrahim et al, 2023). These statistics demonstrate how educational disparities translate into professional underrepresentation, limiting both individual career opportunities and broader technological innovation capacity.

The manufacturing sector exhibits similar patterns, employing three times as many men as women according to the Micro, Small, and Medium Enterprises (MSME) 2017 national survey report (Ugwu, 2018). While Nigeria has the highest number of female entrepreneurs globally, women are predominantly involved in informal sector activities, with over 50% of women in formal sector employment concentrated in teaching, clerical services, and sales rather than technological fields.

Recommendations for Addressing Gender Disparities

Addressing gender disparities in STEM pathways requires comprehensive, multi-level interventions targeting educational, social, and economic barriers. The research suggests implementing gender-sensitive pedagogical approaches across various academic fields to attract more female participants to STEM education (Ibrahim et al, 2023). This includes developing curriculum content that relates STEM subjects to real-world applications and promoting transformative digital education systems that are accessible and relevant to diverse student populations.

Creating gender-friendly work environments represent another crucial intervention area. Labor policies that accommodate family responsibilities, including extended maternity leave, compulsory paternity leave, and flexible work arrangements, could significantly increase women's participation in STEM careers (Odo, 2016). Additionally, implementing strict anti-harassment policies and creating supportive mentorship networks would help address workplace barriers that discourage female participation in technological fields.

Infrastructure and Resource Development

Substantial investment in educational infrastructure represents a fundamental requirement for expanding STEM education opportunities. The research recommends employing adequate numbers of competent computer teachers in each secondary school, conducting urgent ICT training workshops for existing teachers, and providing necessary facilities for effective technology instruction (Odo, 2016). These infrastructure improvements would benefit all students while creating particular opportunities for female students who may lack access to technology resources in other settings.

Partnerships between secondary schools and higher education institutions, such as the University of Nigeria, could provide valuable resources and mentorship opportunities. The University of Nigeria Secondary School's proximity to the main campus creates a model for how such partnerships might function, though expanding these relationships to include specific gender inclusion initiatives would enhance their effectiveness for addressing STEM disparities.

Conclusion

The investigation of gender disparities in STEM pathways within Nsukka secondary schools reveals persistent and significant challenges that limit female participation in robotics and software development education. Despite substantial student interest in programming and technological applications, with over 58% of students supporting curriculum inclusion of programming instruction, systemic barriers continue to discourage female engagement with these critical fields. The convergence of cultural stereotypes, infrastructure limitations, and pedagogical approaches that fail to address diverse learning needs creates cumulative disadvantages for female students seeking to pursue technological careers.

Current initiatives, including robotics competitions, international collaboration programs, and targeted gender inclusion efforts by organizations such as NWiSTEM, provide important foundations for addressing these disparities. However, the scale and persistence of the challenges require more comprehensive interventions addressing infrastructure development, teacher training, curriculum reform, and cultural change. The potential for transformation is significant, as evidenced by successful programs such as "Project 10,000 Kids" and the growing international recognition of Nigerian student capabilities in robotics and programming competitions.

Moving forward, the development of gender-inclusive STEM education in Nsukka will require coordinated efforts among educational institutions, government agencies, private sector organizations, and community stakeholders. The University of Nigeria's leadership position in the region creates unique opportunities for implementing innovative approaches that could serve as models for broader national adoption. By addressing the identified barriers through targeted interventions focused on infrastructure, pedagogy, and cultural change, Nsukka's secondary schools can become leaders in creating equitable pathways for all students to participate in Nigeria's technological future.

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