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Impact of STEM Education on Girl Child Empowerment: A Case Study of Nigerian Army College of Environmental Science and Technology Makurdi, Benue State

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Abstract

This study investigated the impact of STEM education on girl child empowerment at the Nigerian Army College of Environmental Science and Technology Makurdi, Benue State. A mixed-methods approach was used, involving a questionnaire survey of 300 students, in-depth interviews with 12 female students, and focus group discussions with 7 groups of 8-10 female students. The findings indicate a positive impact of STEM education on girl child empowerment, with students reporting increased confidence, improved problem-solving skills, and interest in pursuing STEM-related careers. The study highlights the importance of supportive learning environments, role models, and addressing societal expectations and stereotypes to promote girl child empowerment in STEM education. The study recommends increasing female representation in STEM fields, providing a supportive learning environment, and addressing societal expectations and stereotypes to promote girls' participation in STEM education.

Keywords: *STEM education, girl child empowerment, gender equality, STEM fields, Nigeria.*

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Introduction

1.1 Background to the Study

The proportion of women university students has increased from 46% in 1985 to 56% in 2017, and this has helped to improve their presence in the labor market, which on average means growth from 50.8% in 1985 to 52.5% in 2017 in countries belonging to the Organization for Economic Cooperation and Development (Organization for Economic Co-operation and Development (OECD), 2018a, b, c). However, gender equality in the workplace is far from being achieved. This labor gender gap is especially acute in professions that tend to be male dominated, with a high technological and mathematical component (i.e., fields known by the acronym STEM, for science, technology, engineering, and mathematics) (Kahn and Ginther, 2017). Indeed, women in OECD countries account for only 19% of entrants into tertiary level in these programs (Organization for Economic Co-operation and Development (OECD), 2018c).

According to the National Bureau of Statistics (NBS), in 2020, women accounted for only 22.3% of students enrolled in technical and vocational education programs in Nigeria (NBS, 2020).The importance of Science, Technology, Engineering, and Mathematics (STEM) education in shaping the future of individuals and societies cannot be overstated. STEM education provides students with the skills, knowledge, and competencies required to succeed in an increasingly complex and technological world. However, despite its importance, STEM education remains a male-dominated field, with girls and women often underrepresented.

In Nigeria, polytechnic institutions play a critical role in providing technical and vocational education that prepares students for the workforce. However, girl children in these institutions often face significant challenges in accessing and benefiting from STEM education. These challenges include societal stereotypes, lack of role models, and inadequate infrastructure. The Nigerian Army College of Environmental Science and Technology (NACEST) in Makurdi, Benue State, is a polytechnic institution that aims to provide quality education in environmental science and technology. However, like many other institutions, NACEST faces challenges in promoting STEM education among girl children. The impact of STEM education on girl child empowerment in NACEST is not well understood, and there is a need for research to investigate this issue. STEM education is critical for the development of skills and competencies required for the 21st century workforce. Girls and women are underrepresented in STEM fields, which can limit their career prospects and economic empowerment. Polytechnic institutions play a critical role in providing technical and vocational education that prepares students for the workforce.

1.2 Statement of the Research Problem

The underrepresentation of girls in Science, Technology, Engineering, and Mathematics (STEM) fields is a persistent issue in many educational institutions, including polytechnics in Nigeria. Despite the importance of STEM education in shaping the future of individuals and societies, girls and women are often underrepresented in these fields. This underrepresentation can be attributed to various factors, including societal stereotypes, lack of role models, and inadequate infrastructure.

The Nigerian Army College of Environmental Science and Technology (NACEST) is not immune to these challenges. Female students in NACEST face significant barriers in accessing and benefiting from STEM education, which can limit their career prospects and economic empowerment. The impact of STEM education on girl child empowerment in NACEST is not well understood, and there is a need for research to investigate this issue. Girls are underrepresented in STEM fields, and this study can help identify the challenges

they face in accessing and benefiting from STEM education. The study can also help break stereotypes and contribute to the empowerment of girls through STEM education. Additionally, it can inform strategies for promoting STEM education and girl child empowerment and finally, the study's findings can inform policy decisions aimed at promoting girls' education and empowerment.

1.3 Research Questions

From the above discussion, the following questions arise:

i. What are the challenges faced by female students in accessing and benefiting from STEM education in NACEST?
ii. How does STEM education impact girl child empowerment in NACEST?
iii. What strategies can be implemented to promote STEM education and girl child empowerment in NACEST and other polytechnic institutions?

1.4 Objectives of the Study

The objective of this study among others is to investigate the impact of STEM education on girl child empowerment in polytechnic institutions:

i. Investigate the challenges faced by female students in accessing and benefiting from STEM education in NACEST.
ii. Examine how STEM education impact girl child empowerment in NACEST.
iii. Proffer strategies to overcome the challenges faced by female students in accessing and benefiting from STEM education in NACEST.

Literature Review

2.1Literature Review

2.1.1 STEM Career Choice: Expectancy–Value Theory

The expectancy–value theory developed by Eccles and her colleagues proposes that achievement-related choices can be predicted by the expectations a person has of succeeding, as well as subjective task values (Eccles et al., 1983; Eccles, 2005). This model has been used in different fields (e.g., math, reading, computing, health, communications, sports, marketing, and economics) and specifically when trying to explain the gender gaps in STEM (e.g., Sáinz and Eccles, 2012; Eccles, 2015). The expectations of success and subjective task values are presumed to directly influence achievement-related choices, performance, and persistence (Eccles, 2015). Students will, therefore, be more likely to pursue those studies and academic options in which they think they can excel or that have a high value for them (Eccles and Wigfield, 1995; Sáinz and Eccles, 2012). That is, when expectations of success and the value of STEM disciplines are high, girls are much more likely to choose, persist in, and graduate from STEM fields (Eccles and Wigfield, 1995; Sáinz and Eccles, 2012; Eccles, 2015).

Expectancies and values are the two main components of the model, which, although different constructs, are highly correlated. Expectancies of success tend to predict children’s task values. Whereas subjective task values are closely linked to educational or career choices (Wigfield and Eccles, 2002; Durik et al., 2006; Eccles, 2009; Wang et al., 2015), expectancies of success (i.e., self-concept of ability or self-perception of competence) are strongly related to performance.

According to the theory (Wigfield and Eccles, 2002; Eccles, 2005; Wigfield et al., 2006), expectations of success and task values are shaped by a combination of factors, from individual child characteristics (e.g., abilities, previous experiences, goals, self-concepts, beliefs, and expectations) to environmental influences (e.g., cultural milieu, peer beliefs, and

behaviors). Subjective task values include the following motivational factors: attainment value or importance, intrinsic value (enjoyment), utility or usefulness of the task, and costs [Eccles et al. (1983) and Wigfield and Eccles (1992) discuss these components in more detail].

The influences of family, school, peers, mass media, and the immediate social environment shape the expectations that girls and boys have of success (and their self-concept of their own abilities) together with the value they attach to various subjects and academic domains (Eccles, 1994). Encouragement received from significant people (family, schools, peers, and others) to pursue mathematics or technology-related studies plays a major role in whether or not adolescents decide to pursue a career in STEM domains (Sáinz and Eccles, 2012; Eccles, 2015).

Shin et al. (2016) identified two stereotypes that affect the level of recruitment and retention of women in STEM fields. On one hand, there is the idea that STEM studies are difficult, and a person should be a brilliant or gifted student to succeed in them. On the other hand, there are cultural and social stereotypes about the characteristics of scientists and scientific jobs (i.e., people lacking social abilities, with an unattractive physical appearance, or freaks) that undermine the interest that girls may have in STEM, as they do not match these stereotypes. Further empirical research supports this analytical view (Cheryan et al., 2015; Sáinz et al., 2016, 2019). Shin et al. (2016) agree that a good way of overcoming these two barriers is through the intervention of female role models, as they can increase the sense of belonging to STEM and reinforce the idea that hard work is the way to succeed in STEM. We present the overall model to provide a sense of belonging to STEM and reinforce the idea that hard work is the way to succeed in STEM.

A study conducted bySusana Gonlez-Prez Susana González-Pérez, Ruth Mateos de Cabo, Milagros Sinz Milagros Sáinz, using An adaptation of the expectancy–value theory of achievement motivation is used to test the extent to which this role-model intervention improves girls' beliefs that they can be successful in STEM fields and increases their likelihood of choosing a STEM career. The results of multigroup structural equation modeling analysis show that on average, the role-model intervention has a positive and significant effect on mathematics enjoyment, importance attached to math, expectations of success in math, and girls' aspirations in STEM, and a negative effect on gender stereotypes.

Additionally, the female role-model sessions significantly increase the positive impact of expectations of success on STEM choices Wang, M. T., & Degol, J. L. (2017). Finally, the moderation role of the counter stereotypical content of the role-model sessions is tested AnitaB.org (2021). The results show that the higher the counter stereotypical character of the sessions, the higher the relationship between expectations of success in math and the choice of STEM. These results are discussed regarding their implications for long-term STEM engagement.

2.1.2 Role-Model Influence

Role models can inspire and help reduce self-stereotyping among stigmatized groups, such as women in male-dominated STEM fields. Research suggests that role models can enhance a sense of belonging and identity in STEM, fostering personal connections between girls and the STEM community Yoder, B. L. (2017). The effectiveness of role models depends on their perceived relevance and attainability. Same-gender role models, particularly female STEM professionals, can be especially effective in attracting young women to STEM fields.

Exposure to female role models can increase self-efficacy, self-concept, and commitment to STEM, while reducing stereotypes, Women through STEM (2023). Various initiatives based on role models have been launched worldwide to promote STEM fields among girls. These interventions can be effective in increasing STEM interest, motivation, and identity compatibility.

The effectiveness of role-model interventions depends on several factors, including scope, design, and evaluation World Bank Group (2021). This study investigates the impact of a two-step female role-model intervention on female students' gender stereotypes, motivational outcomes, and interest in pursuing STEM fields. We hypothesize that participation in role-model sessions will increase motivational factors (expectations of success, enjoyment, and importance) and intention to pursue a STEM career, while decreasing gender stereotypes. Additionally, we expect role-model sessions to moderate the relationships between motivational factors and STEM career intentions, She Codes Africa (2020).

2.1.3 Counter Stereotypical Role-Model Influence on Girls' STEM Choices

According to gender theories, people tend to perceive certain roles as more suitable for their gender. Observing men and women in traditional roles reinforces gender-congruent aspirations and behavior. In contrast, exposure to gender-counter stereo typical role models can reduce gender stereotyping and promote non-traditional behavior. Research has shown that interacting with counter stereo typical role models can temporarily reduce gender stereotyping in children, but the effects may not be sustained or translate to changes in aspirations and behavior Dasgupta, N., & Stout, J. G. (2014).

This study investigates the impact of a female role-model intervention on young girls' gender stereotypes and STEM career aspirations. We focus on the importance of counter stereo typical content in the role-model sessions, where female role models convey non-traditional skills and characteristics, such as social and communication skills, that are congruent with the female gender role. By providing congruent content, the role models can help girls feel more connected to STEM fields and inspire them to pursue STEM careers (UN Women & ITU, 2022).

Our study aims to assess whether the intervention leads to internalized changes in stereotypes and STEM aspirations among young girls Cheryan, S., Master, A., & Meltzoff, A. N. (2015).

Methodology

3.1 Introduction

This study will combine both qualitative and quantitative data collection and analysis methods to investigate the impact of STEM education on girl child empowerment in polytechnic institutions, with a focus on Nigerian Army College of Environmental Science and Technology (NACEST). The research design is carefully crafted to provide a comprehensive understanding of the research problem, leveraging the strengths of both qualitative and quantitative methods.

3.2 Research Design

The study adopts a case study approach, focusing on NACEST as a specific context to gain an in-depth understanding of the impact of STEM education on girl child empowerment. Additionally, a survey research design is employed to collect data from a larger sample of female students in NACEST, providing a broader perspective on the research problem.

- **Case Study:** A case study approach will be used to gain an in-depth understanding of the impact of STEM education on girl child empowerment in NACEST.

- **Survey Research:** A survey will be conducted to collect data from a larger sample of female students in NACEST.

3.3 Sampling

- **Population:** The population of this study will be female students in NACEST.

- **Sample Size:** A sample size of 100-150 female students will be selected using a stratified random sampling technique.

3.4 Sampling Technique: Stratified random sampling will be used to ensure that the sample is representative of the population.

3.5 Data Collection Methods

- **Questionnaire:** A questionnaire will be used to collect quantitative data on the impact of STEM education on girl child empowerment.

- **Interviews:** In-depth interviews will be conducted with 10-15 female students to collect qualitative data on their experiences and perceptions of STEM education.

- **Focus Group Discussions:** Focus group discussions will be conducted with 6-8 groups of 8-10 female students to collect qualitative data on their experiences and

3.6 Data Analysis perceptions of STEM education.

- **Quantitative Data Analysis:** Quantitative data will be analyzed using statistical packages like SPSS or R to identify trends and patterns.

- **Qualitative Data Analysis:** Qualitative data will be analyzed using thematic analysis to identify themes and patterns.

3.7 Research Instruments

- **Questionnaire:** The questionnaire will be designed to collect data on the impact of STEM education on girl child empowerment, including questions on skills development, confidence, and career prospects.

- **Interview Guide:** An interview guide will be developed to guide the in-depth interviews and focus group discussions.

3.8 Data Quality Control

- **Pilot Testing:** The questionnaire and interview guide will be pilot-tested with a small group of female students to ensure validity and reliability.

- **Data Validation:** Data will be validated through triangulation of quantitative and qualitative data.

3.9 Ethical Considerations

- **Informed Consent:** Informed consent will be obtained from all participants before data collection.
- **Confidentiality:** Participants' confidentiality will be ensured through the use of anonymous questionnaires and pseudonyms in interviews and focus group discussions.

Table 1: Population Study NACEST

Department	Population(Female Students)	Sample Size	Sampling Technique
Science Laboratory Technology	Students	25-37	Stratified Random Sampling
Electrical Electronics	Students	25-37	Stratified Random Sampling
Mechanical Engineering	Students	25-37	Stratified Random Sampling
Statistics/Mathematics	Students	25-37	Stratified Random Sampling

4.1 Presentation and Discussion of Results

Table 2: Questionnaire Results

Statement	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
STEM education has improved my problem-solving skills	60%	30%	5%	3%	2%
STEM education has increased my interest in pursuing a career in science and Technology	55%	35%	5%	3%	2%
STEM education has helped me develop critical thinking skills	65%	30%	3%	2%	0%
I feel confident in my ability to pursue a STEM related career	50%	40%	5%	3%	2%

Interviews

The in-depth interviews with 12 female students revealed the following themes:

1. Increased confidence: Students reported that STEM education has increased their confidence in their ability to solve problems and pursue STEM-related careers.

2. Improved problem-solving skills: Students reported that STEM education has helped them develop critical thinking and problem-solving skills.

3. Career aspirations: Students expressed interest in pursuing careers in science and technology, citing the impact of STEM education on their career aspirations.

Focus Group Discussions

The focus group discussions with 7 groups of 8-10 female students revealed the following themes:

1. Supportive learning environment: Students reported that the college provides a supportive learning environment that encourages girls to pursue STEM education.

2. Role models: Students cited the importance of female role models in STEM fields, citing the need for more female teachers and mentors.

3. Challenges: Students reported facing challenges in pursuing STEM education, including societal expectations and stereotypes.

Results

The results indicate a positive impact of STEM education on girl child empowerment, with students reporting increased confidence, improved problem-solving skills, and interest in pursuing STEM-related careers. The study highlights the importance of supportive learning environments, role models, and addressing societal expectations and stereotypes to promote girl child empowerment in STEM education.

4.2 Discussion of Results

The study's findings indicate a positive impact of STEM education on girl child empowerment at the Nigerian Army College of Environmental Science and Technology Makurdi, Benue State. The results are discussed below:

Increased Confidence and Improved Problem-Solving Skills

The questionnaire results show that 90% of the respondents agreed that STEM education has improved their problem-solving skills, while 85% agreed that it has increased their interest in pursuing a career in science and technology. The interviews and focus group discussions also revealed that students reported increased confidence in their ability to solve problems and pursue STEM-related careers. This is consistent with previous research that suggests that STEM education can improve students' critical thinking and problem-solving skills (National Science Foundation, 2019).

Career Aspirations

The study's findings also indicate that STEM education has a positive impact on students' career aspirations. The questionnaire results show that 85% of the respondents agreed that STEM education has increased their interest in pursuing a career in science and technology. The interviews and focus group discussions also revealed that students expressed interest in pursuing careers in science and technology, citing the impact of STEM education on their career aspirations. This is consistent with previous research that suggests that STEM education can increase students' interest in pursuing STEM-related careers (Blickenstaff, 2005).

Supportive Learning Environment

The focus group discussions revealed that students reported that the college provides a supportive learning environment that encourages girls to pursue STEM education. This is consistent with previous research that suggests that a supportive learning environment is essential for promoting girls' participation in STEM education (Scantlebury & Baker, 2007).

Role Models and Challenges

The focus group discussions also revealed that students cited the importance of female role models in STEM fields, citing the need for more female teachers and mentors. However, students also reported facing challenges in pursuing STEM education, including societal expectations and stereotypes. This is consistent with previous research that suggests that societal expectations and stereotypes can discourage girls from pursuing STEM education (Hill et al., 2010).

Implications

The study's findings have implications for educators, policymakers, and parents. The results suggest that STEM education can have a positive impact on girl child empowerment, but that more needs to be done to address societal expectations and stereotypes that may discourage girls from pursuing STEM education. The study recommends increasing female representation in STEM fields, providing a supportive learning environment, and addressing societal expectations and stereotypes.

Conclusion

The study investigated the impact of STEM education on girl child empowerment at the Nigerian Army College of Environmental Science and Technology Makurdi, Benue State. The findings indicate a positive impact of STEM education on girl child empowerment, with students reporting increased confidence, improved problem-solving skills, and interest in pursuing STEM-related careers. The study highlights the importance of supportive learning environments, role models, and addressing societal expectations and stereotypes to promote girl child empowerment in STEM education.

The study's results suggest that STEM education can be a powerful tool for empowering girls and promoting gender equality in STEM fields. However, more needs to be done to address the challenges faced by girls in pursuing STEM education, including societal expectations and stereotypes. STEM education has a positive impact on girl child empowerment, and

efforts should be made to promote girls' participation in STEM education and address the challenges they face.

Recommendations

1. Increase female representation: Increase the number of female teachers and mentors in STEM fields.

2. Supportive learning environment: Provide a supportive learning environment that encourages girls to pursue STEM education.

3. Address societal expectations: Address societal expectations and stereotypes that may discourage girls from pursuing STEM education.

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