GENDER AND ENGINEERING: EVOLVING ACTION TO ENCOURAGE WOMEN IN ENGINEERING FOR SUSTAINABLE ECONOMIC GROWTH AND DEVELOPMENT.

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ABSTRACT

Lack of interest of women in studying a field of study related to science, technology, engineering and mathematics (STEM) and their inadequately representation in the engineering industries is of a significant concern to the economic growth and development of a nation. Therefore, any possible solution must be employ to combat these growing challenges. Communities and societal re-orientation, government agencies and industries constitute of women, educational sector among others are the sure ways to surmount these challenges. In this research, a descriptive statistic was used to conduct the study in Federal Polytechnic Ilaro, Ilaro, Ogun State, Nigeria. A sample of ten (10) STEM and twenty (20) non- STEM female National Diploma II (ND II) students in various programmes were selected within the polytechnic. The study was guided by two research questions and summarized data from a sample using indexes mean and standard deviation. A standard deviation value close or wide apart was used to determine the homogeneity in opinion among the respondents. The paper also intended to addresses factors affecting engagement of students in science and mathematics in school, and STEM career pathways, the lower rate of women in STEM and what factors impact their participation in STEM. Closing the gender gap in science is of critical importance for all countries because failure to do so means the loss of vast human resources that could contribute to national development and could further entrench gender inequality in society.

Keywords: *STEM, gender gap, societal re-orientation, industry, economic growth.*

1. INTRODUCTION

Science, Technology, Engineering, and Mathematics (STEM) are widely regarded as critical to the national economy (Fensham, 2008). There is no significant change to the record of the fewer number of women who choose to study careers related to Science, Technology, Engineering and Mathematics (STEM) to date despite the great strides made toward gender equality over the last century. Women are often underrepresented in the field of engineering or in the profession of engineering and technology, yet many have contributed to the diverse fields of engineering historically (Julian, T., Langdon, D., Beede, D., McKittrick, G., Khan, B., & Doms, M. 2011).

According to (Julian et al, 2011) women in technology study, many challenges still need to be addressed to solve this problem from persistent gender bias in the workplace to continued lack of female mentors. Three of the most common challenge that women encounter in the engineering profession include: unequal growth opportunities compared to men, lack of female role models (or mentors) in the field and gender bias in the workplace. One of the primary measures to put into consideration against diversity gap in STEM field is the cultural change (Fensham 2018). This does not mean cultural change in workplace alone, but also in a broader society. Therefore, there are things we can do to bring about this change both institutionally in our industries and in the wider community.

Addressing the problem of unconscious bias is part of the cultural change. For example majority of the software developers in many companies are men, people may subconsciously believe that men are therefore better at software development. It may not happen to them to explore candidates that do not meet the stereotype for that role. And women who see that most software engineer are men may not even consider it as a potential career path to them. There are institutional things that could be done to change this. One would try to create a policy of interviewing at least one diversity candidate for every hiring opportunity.

With more women in STEM fields, the national wage gap would likely shrink. Social status is often associated with a greater fiscal income, and professions in the STEM fields are seen as more prestigious within the labor force. This contributes to the divide of social status between men and women because there are currently far less women with

these occupations than men (Xie & Shauman, 2005). It is clear that we need more women in STEM professions, but in order to make this happen, we need to determine what factors impact their participation.

1.1 Factors Affecting Engagement Of Students in Science and Mathematics in School

Student Attitude to STEM: Lack Of Interest And Self Confidence

Interest in a particular programme is closely linked to good academic performance and Interest must be supported by ability and self-confidence to achieve a goal. Females with genuine interest in engineering have higher self confidence in their abilities to participate in engineering programmes and to have good/better academic performance. It is well known that females are more prone to low self-confidence leading to anxieties and doubt about their choices in life. Some girls and women have doubt about their ability to good academic scores in the engineering programmes, while others lack courage to venture in to engineering programmes (Adlyn, 2013). Even when discouraged, possessing self-confident can help female engineering undergraduates to excel and persevere in the programme.

Role Models in Stem: Lack of Awareness, Career Counseling and Mentoring

Role models, mentors and counsellors are like guides who can help in career advancement for women engineering. Their activity produces good attitudes or reduces negative stereotypes concerning women in engineering. Such mentor/role-model relationship can help female students on techniques to handle the "feelings of isolation and lack of support among women in STEM fields" especially engineering (Amelink, 2008). With low female engineers in academia in Nigerian universities, such guidance is insufficient (Aderemi, H. O., Hassan, O. M., Siyanbola, W. O., and Taiwo, K. 2013). Due to this uneven gender ratio, it is not easy to find female mentors in STEM fields. According to (Olatundun, E., Archibong, F., Ikutegbe, C., Ogunmola, E., and Alege, M. 2014), most of female respondents that performed excellently in mathematics and sciences refuse to study engineering because of lack of engineering awareness in pre-tertiary levels of education. Without pre-collegiate engineering classes or awareness, some girls do not possess the interest and/or academic qualifications to enter engineering programmes. Also, with few or no advice from role models, young girls may shy away from engineering programmes and the women who enrol in the programme tend to experience difficulties adjusting to engineering academic life therefore it may take a lot of time to find balance in academic, family and social lifestyles (Amelink, 2008).

The Science Gender Gap: Gender Stereotyping and Disparity

Gender stereotyping has lead to gender disparity in engineering and technical education. In many African countries, girls' exclusion from science can be attributed largely to the construction of feminine identities, ideologies of domesticity and gender stereotypes (wawasi, 2008). Formal and informal socio-cultural norms and expectations about the role of females in society have tremendous effects on girls' educational opportunities, learning outcomes and decisions about study and work. At the most basic level, obstacles to school access and retention remain fundamental barriers to girls' participation in science, both as children and adults. Girls outnumber boys among children out of school, and they are more likely to begin schooling at a later age. In Nigeria, late school entry is a particular problem among poor children and girls. Less than 50 percent of the poorest girls are enrolled in school at age six. Girls also face greater constraints on pursuing their studies due to household demands on their labor, threats to their physical safety, lack of necessary sanitation facilities at school and societal beliefs that privilege investments in boys' education (Maureen, 2006). Beyond access, cultural biases that impede girls' learning and pursuit of science are significant. Gender biases and discrimination play out acutely with respect to science, particularly the physical sciences, engineering, mathematics and to some extent computer science, which continue to be seen as the domain of males (Dale, B. and Kathryn, S. 2007). Science education in particular, are often viewed as being of less value to girls, given the cultural expectations about their primary roles as wives and mothers. Parents may directly dissuade girls from pursuing science or indirectly convey their differing expectations by insisting that boys take science subjects and leaving girls to choose what they want to study. Girls themselves—as well as their families, teachers and school peers—question the relevance of science to their own lives (Hassan, 2000). People may even doubt that a woman can be trusted to fly a plane or supervise a road's construction, which are viewed as entirely a man's domain. Such beliefs have a negative impact on girls' practical and academic interest and learning in science. In many countries, studies have shown that girls, on average, tend to perceive science as difficult, uninteresting or unappealing in the future prospect it offers. In addition, (Adlyn 2013), point out that female student gave opinions that the lack of interest and their poor attitude to engineering subjects can be traced to gender stereotyping".

1.2 THE LOWER RATE OF WOMEN IN STEM AND WHAT FACTORS IMPACT THEIR PARTICIPATION

There are three main types of factor identified here for the participation of women in STEM; gender stereotyping, social and psychological barriers, perceptions of the nature of STEM work. Some of these studies explicitly refer to engineering as part of the issue relating to STEM.

Table 1. Percentage of Female University Students Enrolled in Science and Technology Courses in 12 Nigerian States, "1998–99 to 2001–2002".

YEAR	SCIENCE	TECHNOLOGY
1998-1999	**32.2**	**17.3**
1999-2000	**33.9**	**16.1**
2000-2001	**29.3**	**14.2**
2001-2002	**25.9**	**23.4**

Source: UNESCO Federal Office of Statistics, 2003 abstracts.

a) Gender Stereotypes

Women are historically stereotyped as being inadequate at math and science. Women face this stereotype throughout years of schooling in math and science classes as well as in the workplace, which impacts their participation in math and science professions. Given that men do not face a similar negative stereotype, we would not expect men to be as hindered as women, and would not be as likely to worry that they are being judged, critiqued, and evaluated by their peers based on an unwarranted negative stereotype. The pervasive stereotypes about women in society can have a negative impact on their math and science achievement, and cause them to underperform (Spencer et al 1999).

b) Social and Psychological Barriers

They found that in early years, without any conscious intention by parents, young girls receive less exposure to and understanding of mathematical and scientific ideas from their parents than boys. One possible reason for this practice, as reported, was parental beliefs that boys were more interested and capable in STEM subjects and that STEM subjects are more difficult and less important for girls than boys. Similarly, without conscious intention, teachers also convey gender stereotyped views regarding STEM education to the children in early years. Along with influences from parents and teachers, when girls move from childhood to adolescence, their self-perceptions and attitudes to STEM are also influenced by their peers and the media. As most media portray STEM as a male dominated domain, it is not surprising that fewer females would perceive STEM as an area of interest. Parental expectation for careers plays a vital role in shaping career aspirations. For instance, mothers' expectations about whether their male and female children should have gender-stereotyped careers are significantly correlated with their children's gendered career expectations. When women enter STEM majors and careers, they may be prone to 'prevention focus' as a result of stereotype threat (a decrease in performance that can occur when there is an expectation that women will perform at a lower level than men) in either study environment or workplace environment.

c) Nature of Stem Work

(Marginson et al. 2013) reported that the perceived nature, organization and career pathways of STEM fields of study and employment are a barrier for women's participation in STEM. It appears that for women it is incredibly difficult to have a successful career, social life, and family life without compromising one or more aspects. Firstly, it is typical that women in STEM fields who want to raise a family have to make sacrifices to their career more commonly than men who have children (Ceci et al., 2009). Social norms dictate that men are the breadwinners and women are the caregivers. Even though modern family structures are redefining these roles, there is still a conservative nature and stigma surrounding women in the workforce.

2. METHODOLOGY

In this work, a descriptive research was used to conduct the study in Federal Polytechnic Ilaro, Ilaro, Ogun State, Nigeria. A sample of twenty (20) non- STEM female National Diploma II (ND II) students in various programmes were selected within the polytechnic. The study was guided by two research questions on which a structured questionnaire of 10 item five-point ordinal category (Likert scale) type is used. The 5-point Likert format comprised Totally Agree (TA) = 5, Agree (A) = 4, Neutral (N) = 3, Disagree (D) = 2 and Totally Disagreed (TD) = 1. To determine the reliability of the questionnaire, 10 copies were administered to 10 female engineering students who were not part of the sample and a reliability coefficient of 0.805 was obtained using Cronbach Alpha Coefficient method which shows that the scale used was reliable. The data collected were analyzed using statistical mean and standard deviation. The decision rule was based on real limits of numbers of 4.50- 5.00 (Totally Agree), 3.50 – 4.49 (Agree), 2.50 – 3.49 (Neutral), 1.50 – 2.49 (Disagree), 0.50-1.49 (Totally Disagreed) were used. Therefore, each questionnaire item having mean value greater than or equal to 3.50 was accepted, while any item that had mean value range of 2.50 to 3.49 was neutral and item with mean value less than or equal to 2.49 was rejected. Standard deviation values close or wide apart was used to determine the homogeneity in opinion among the respondents

Research Questions

1. Factors affecting engagement of female students in STEM?
2. What factors keep motivating female students to continue in STEM despite challenges?

3. RESULT AND DISCUSSION

Table 2. Data Analysis

Question 1. ITEM STATEMENT	OBSERVATION (X)	X-mean	(X-mean)^2	Remark
Pysical disability	4	-2.6	6.76	Rejected
Poor learning environment	7	0.4	0.16	Rejected
Discouragement from parent	6	-0.6	0.36	Rejected
Physical harrasment due to gender difference	10	3.4	11.56	Neutral
Difficulty and too much academic workload	11	4.4	19.36	Accepted
Lack of interest / background knowledge	11	4.4	19.36	Accepted
Limited lecturer to student integration	3	-3.6	12.96	Rejected
Underrated self ability and hardwork	11	4.4	19.36	Accepted
Poor practical facility	5	-1.6	2.56	Rejected
I do not like science subject	0	0	0	Rejected
Question 2. ITEM STATEMENT				
Self confidence	11	4.4	19.36	Accepted
Friends and family	3	-3.6	12.96	Rejected
Councellor / Mentor	11	4.4	19.36	Accepted
Job prospect	3	-3.6	12.96	Rejected
Government support	3	-3.6	12.96	Rejected
Sum	99	6.6	170.04	
Count (N)	15	15	15	
Average (mean)	6.6			
Variance (S^2)			12.14571429	
Standard Deviation (s)			3.485070198	

In Table 2 Question 1, shows the data analysis on factors affecting the engagement of female in engineering programs in the institution where the study was conducted. Items 5, 6 and 8 mean scores above 3.50 thus, these items were accepted as factors affecting the engagement of female in engineering. The respondents had neutral views on item 4 (mean scores range of 2.50 – 3.49), while the rest of the items (mean scores range of (0.50 – 2. 49) were rejected. In Table 2 Question 2, the data analysis showed that only one item (11) was accepted by the respondents as factors that keep them [females] motivated to continue in the engineering programme in the institution where the study was conducted. The remaining four items (12, 13, 14 and 15) were rejected.

4. CONCLUSION

The findings of this study concluded that female engineering students encounter a number of challenges that need to be addressed. The challenges are diverse and rise from a number of sources. Most of the challenges indicated by female students in engineering programmes are not necessarily unique to them; those challenges may be affecting male engineering students as well as students from other faculties of the university. The study also confirmed that female engineering students are motivated by certain factors that enable them continue in their engineering programmes. In particular, the findings showed that discouragement from people have little effect on the determination of female in STEM.

5. RECOMMENDATIONS

There are many factors to address in order to fix the issues of women in STEM, and it is beyond the scope of this research to provide a comprehensive solution. Instead, we will recommend some interventions and restorative strategies that would make a positive impact on women in STEM.

1. Government should improve the learning environment with engineering facilities to execute activities such as include investigative learning, laboratory experience field trips and collaborative work for real life projects, which are important to help engineering students to understand abstract theories and mechanisms related to engineering.

2. Parents and relatives should not discourage the ambitions of female wards from pursuing science courses which may lead to a study of engineering in higher institutions.

3. Women in engineering bodies in Nigeria should visit schools to be role models and counselors to equip female students with knowledge to deal with challenges in engineering programmes.

4. There is need to create programmes for engineering awareness from pre-tertiary levels through guidance and counseling services functional in all educational levels to ensure students get enough information to make the right career choices for themselves. This will create positive perception of engineering careers in the mindset of girls and women

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