STRATEGIES FOR PROMOTING GENDER EQUALITY IN STEM TOWARDS SUSTAINABLE DEVELOPMENT

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Abstract
This study investigated strategies for promoting gender equality in STEM towards sustainable development. Two research questions were posed and one null hypothesis formulated for analysis at 0.05 level of significance. Descriptive survey design was utilized. Sixty-seven (67) secondary school science teachers comprising of 39 males and 28 females, randomly drawn from four secondary schools in Umuahia North Local Government Area in Abia State served as sample. The instrument for data collection was questionnaire. Data were analysed using mean and Chi-square statistics. Results show that; exposing girls/women in STEM to female STEM experts and peers, fostering collaboration between STEM students (boys and girls) and science museums, creating informal STEM learning environment after school activities, fostering collaboration between STEM students and STEM Departments in Universities, promoting opportunities for peer networking and many others are agreed by male and female science teachers as strategies for promoting gender equality in STEM. Chi-square statistics analysis show a no significant difference in the responses of male and female science teachers. Recommendations were made one of which is the need for STEM teachers teaching girls/women studying STEM related subjects in the secondary schools and universities to expose them to female STEM experts and peers for encouragement.

Introduction

Education is central to a country's well-being and sustainable development. According to Lopez-Claros, Augustino, Zahidi and Saadia, (2007), a country that educates its citizens is bound to have its economic productivity rise, maternal and infant mortality rates fall, fertility rates decline, and the health and educational prospects of the next generation improved. Good quality education is an essential tool for achieving sustainability. Which has shown that education can improve agricultural productivity, enhance the status of women, reduce population growth rates, enhance environmental protection, and generally raise the standard of living. Education can enhance sustainable development through promoting the development of the

knowledge, skills, understanding, values and actions required by individuals which will in turn ensure environmental protection and conservation, promotes social equity and encourages economic sustainability. The implication is that the learning process and the outcome of education process should promote critical thinking, problem solving and action which will help in addressing the challenges to sustainable development (UNESCO 2006).

Science, Technology, Engineering, and Mathematics (STEM) education is an education that creates critical thinkers, increases science literacy, and empowers the next generation to be innovators. Innovation we know leads to new products and processes that sustain our economy. There is no doubt that innovation and science literacy depends on a solid knowledge base in STEM. According to Ugwuada (2011), STEM is a curriculum based on the idea of educating students in four specific disciplines - science, technology, engineering and mathematics in an interdisciplinary and applied approach. Explaining further Ugwuada (2011), stressed that rather than teach the four disciplines as separate and discrete subjects, STEM integrates them into a cohesive learning paradigm based on real-world applications. Science, Technology, Engineering, and Mathematics (STEM) play an increasingly important role in addressing critical needs of society and generating innovation that drives the global economy. STEM is important because it pervades every part of our lives. Science is everywhere in the world around us while technology is continuously expanding into every aspect of our lives. Engineering in addition to being the basic designs of roads and bridges, tackles the challenges of changing global weather and environmentally-friendly changes to our home while mathematics is found in activity in our lives (UNESCO 2016). By exposing students to STEM and giving them opportunities to explore STEM-related concepts, they will develop a passion for it and hopefully pursue a job in a STEM field (National Science Foundation, 2016). According to National Science Foundation (2016), a curriculum that is STEM-based has real-life situations to help the student learn. STEM activities provide hands-on and minds-on lessons for students. According to Danmole (2011), the development of any nation begins from the classroom, therefore, Science, Technology, Engineering and Mathematics (STEM) Education is the instrument for change and national development. It is the driving force of the current world and a major instrument of globalization (Dantani and Baba, 2011). STEM education according to Danmole (2011) is the gate way to socio-economic advancement, industrial development and a road to self-reliance. This implies that STEM is the engine room of economic development that can move any country to modernity, self-reliance and industrialization. STEM education prepares graduates for

employment requiring technological knowledge and usable skills in job operation such as planning, quantity and quality control, maintenance and production (Ugwuada, 2011). The implication according to Ugwuada (2011), is that no nation can build a solid technological base for the production of raw materials, goods and services without the application of mathematical, scientific and technological knowledge. There is therefore a need for Nigerian citizens to acquire STEM education especially for the fact that STEM education lays emphasis on the development of skills, abilities, understandings, attitudes, work-habits and appreciation which encompasses knowledge and information needed by graduates to enter or make progress in field of work in a productive basis.

In a globally competitive economy, employers of all shapes and sizes are increasingly looking for workers who are skilled in science, technology, engineering, and mathematics. Unfortunately women face significant wage differentials with respect to their male peers and there is still discrimination in the labour market (Document of European Bank for Reconstruction and Development, 2016). The roles of women and minorities in STEM-related fields have been established to have been increased by initiatives. For a global economy competition, STEM education and careers must be a national priority. The implication is that if STEM education is not improved, Nigeria will continue to fall in world ranking with mathematics and science scores and will not be able to maintain its global position.

Even where many women receive STEM degrees, the industry is still considered to be male dominated. This is why gender equality in the STEM industry is very necessary in fighting inequality everywhere. Although currently as many women and girls as men and boys can be admitted in a school/ university, still fewer women get selected to join the public schools and universities due to their inability to excel in STEM subjects. Reducing the gender gap in Science, Technology, Engineering and Mathematics (STEM) education could help reduce skills gap, increase employment and productivity of women and reduce occupational segregation (National Science Foundation, 2016). This will in turn foster economic growth through higher productivity and increased labour market activity. Despite the importance of STEM education, there is currently a low proportion of women studying and graduating in STEM subjects.

Gender differences in STEM education participation at the expense of girls are visible as early as in early childhood especially in science- and math-related subjects (UN, 2016). Girls according to UN (2016) appear to lose interest in STEM subjects with age, particularly between early and late adolescence. This decreased interest affects participation in advanced studies

at secondary-level. Gender gaps in STEM education participation become more obvious in higher education where female students represent only 35% of all students enrolled in STEM-related fields of study at this level globally (UN, 2016). According to Barka and Aspray (2006), differences are also observed by disciplines, with female enrollment lowest in engineering, manufacturing and construction, natural science, mathematics and statistics and ICT fields. Stressing further Barka and Aspray (2006) opined that significant regional and country differences in female representation in STEM studies can be observed, suggesting the presence of contextual factors affecting girls' and women's engagement in these fields. Women leave STEM disciplines in disproportionate numbers during their higher education studies, in their transition to the world of work and even in their career cycle.

Despite the fact that enabling policy environment and many initiatives are provided to promote women's and girl's education in STEM subjects/disciplines, a number of social-cultural and institutional barriers continue to prevent girls and young women from attending schools and universities and from performing equally to their male classmates (UNESCO, 2010). During childhood and adolescence period, parents expectations of their daughters and masculine stereotypes make growing girls run away from STEM subjects. Peer influence also plays a role in scaring girls from STEM fields. Most science and mathematics classes are vastly outnumbered by boys thereby discouraging their female counterparts. Explaining, Dasgupta and Stout (2014) said that subtle gender bias exist in hiring and promotion, evaluation of scientific work, non-inclusive department climate, juggling work– family responsibilities, lacking female role models and difficulty returning after a family-related pause undermine the retention of women in STEM.

Explaining this further, UNESCO, 2010 opined that generally, female students continue to lag behind in educational achievement especially in secondary and tertiary levels, where girls' enrolment, completion and achievement rates are lower. Even when girls and women perform as well as their male peers on STEM tests or better, many lose interest and do not pursue advanced courses, majors, and careers in STEM, representing an exodus of talent among girls and women who could otherwise become the next generation of scientists, engineers, and creators of technology (Dasgupta, 2011). This disparity and inequality in women in STEM is of great concern to the nation.

Sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs. The importance of linking gender equality with sustainable

development cannot be over emphasized. A nation that aims at achieving a just and sustainable future cannot afford to ignore the rights, dignity and capabilities of women who form almost half the world's population. According to United Nations (2014), for effective sustainability, policy actions for sustainability must redress the disproportionate impact on women and girls of economic, social and environmental shocks and stresses. To improve resource productivity, enhance ecosystem conservation and sustainable use of natural resources, and to create more sustainable, low-carbon food, energy, water and health systems, there is a great need for women's knowledge, agency and collective action. The implication is that there should be gender equality in STEM education which makes it necessary to identify strategies for promoting gender equality in STEM. Hence the need for this study.

The following Research Questions guided the study:

1. What are the mean scores of STEM teachers on the strategies for promoting gender equality in STEM for sustainable development?
2. What are the mean scores of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development?

The Null hypothesis below is tested at $p \leq 0.05$:

- There is no significant difference in the mean scores of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development.

Method

The study utilized descriptive survey research design to identify some strategies for promoting gender equality in STEM towards sustainable development. By the use of purposive sampling 67(45 males and 22 females) STEM teachers from four secondary schools in Umuahia North Local Government Area in Abia State was sampled. The instrument for data collection was the researcher's developed structured questionnaire of the Likert type on strategies for promoting gender equality in STEM towards sustainable development. Two research questions and one hypothesis tested at 0.05 level of significance guided the study. The instrument was validated and the reliability index of 0.76 was obtained. The instrument was distributed to the respondents personally by the researcher and collected back from them after responding to the questions. Data collected was analyzed using mean for the research questions and Chi-Square statistics for the hypothesis.

Result

Table 1: Mean Scores of STEM teachers on the strategies for promoting gender equality in STEM for sustainable development.

S/N	ITEM	SA	A	D	SD	Mean	Remarks
1.	Expose girls/women in STEM to female STEM experts and peers.	50	17	-	-	3.75	Agree
2.	Fostering collaboration between STEM students (both boys and girls) and science museums.	60	7	-	-	3.90	Agree
3.	Creating informal STEM learning environment after school activities.	53	14	-	-	3.79	Agree
4.	Fostering collaboration between STEM students and STEM Departments in Universities.	13	52	2	-	3.01	Agree
5.	Promoting opportunities for peer networking.	52	15	-	-	3.78	Agree’
6.	Providing role models and mentorship for women.	60	7	-	-	3.90	Agree
7.	Conducting blind review of applicants (both males and females) and other work products.	50	17	-	-	3.75	Agree
8.	Fostering an inclusive climate in STEM Departments.	52	12	3	-	3.73	Agree
9.	Supporting work-life balance for STEM faculty.	50	17	-	-	3.75	Agree
10.	Encouraging professional development.	65	2	-	-	3.97	Agree

Table 1 above clearly showed that all the items have mean values greater than 2.5 which is the mean value of the four point scale used in the study. This means that all the STEM teachers agreed that these items are all strategies for promoting gender equality in STEM for sustainable development.

Table 2: Mean Scores of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development.

S/N	ITEM	SA		A		D		SD		Mean		Remarks
		M	F	M	F	M	F	M	F	M	F	
1.	Expose girls/women in STEM to female STEM experts and peers.	38	20	15	2	-	-	-	-	4.4	3.9	Agree
2.	Fostering collaboration between STEM students (both boys and girls) and science	42	18	3	4	-	-	-	-	4.3	3.8	Agree

	museums.											
3.	Creating informal STEM learning environment after school activities.	33	20	12	2	-	-	-	-	3.7	3.9	Agree
4.	Fostering collaboration between STEM students and STEM Departments in	3	10	40	12	2	-	-	-	3.0	3.5	Agree
5.	Universities.	30	22	15	-	-	-	-	-	4.0	4.0	Agree
6.	Promoting opportunities for peer networking.	41	19	4	3	-	-	-	-	3.9	3.9	Agree
7.	Providing role models and mentorship for women.	29	21	16	1	-	-	-	-	3.6	4.0	Agree
8.	Conducting blind review of applicants (both males and females) and other work products.	32	20	10	2	3	-	-	-	3.6	3.9	Agree
9.	Fostering an inclusive climate in STEM Departments.	32	18	13	4	-	-	-	-	3.7	4.0	Agree
10.	Supporting work-life balance for STEM faculty. Encouraging professional development.	43	22	2	-	-	-	-	-	4.0	4.0	Agree

Result in table 2 shows that all the items have mean values greater than 2.5 meaning that all the STEM teachers, both males and females agreed that the ten items listed above are all strategies for promoting gender equality in STEM for sustainable development.

Table 3: X^2 values of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development.

SEX		**SA**	**A**	**D**	**SD**	**Total**
MALE	**45**	32	13 (30)	- (11)	- -	**45** -
FEMALE	**22**	19	3 (15)	- (5)	- -	**22** -
TOTAL	**67**	**51**	**16**	**-**	**-**	**67**

X^2cal = 1.56, X^2crit/tab = 7.815, df = 3.

Table 3 clearly showed that X^2 calculated value of 1.56 is less than the X^2 critical/ table value of 7.815. The null hypothesis of no significant difference is accepted. This therefore means that there is no significant difference in the mean scores of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development.

Discussion

Tables 1 and 2 showed that all the items have mean values greater than 2.5 which means that all the teachers both males and females agreed that exposing girls/women in STEM to female STEM experts and peers, fostering collaboration between STEM students (both boys and girls) and science museums, creating informal STEM learning environment after school activities, fostering collaboration between STEM students and STEM Departments in Universities, promoting opportunities for peer networking, providing role models and mentorship for women, conducting blind review of applicants (both males and females) and other work products, fostering an inclusive climate in STEM Departments, supporting work-life balance for STEM faculty and encouraging professional development are strategies that could be used to promote gender equality in STEM for sustainable development.

This result is also in agreement with Stout, Ito, Finkelstein, & Pollock, (2013), who opined that access to role models and mentors influences successful professional development. They went further to explain that young adults identify with successful female role models whose presence allows them to think. When STEM professors are female, their presence in classrooms has clear benefits for female students. For example, in one of their study, they found that female students taking college courses in calculus taught by female lecturer, felt more confident about their mathematics ability and viewed mathematics as central to their sense of self, which in turn increased their intentions to pursue STEM careers.

Dasgupta, Hunsinger, & Scircle, (2014), maintain that role models also serve as mentors who guide professional development, champion students' work, and broaden their professional network. They believe that a dearth of role models means undergraduate women are less likely to learn how to navigate the path from their first year in college to STEM careers, which involves the development of social capital necessary to persist in STEM.

This result also agrees with Stout, Dasgupta, Hunsinger, & McManus, (2011), who opined that bringing young people into the lab for scientific demonstrations, giving a science workshop at a local school, or collaborating

with the science teacher to organize a relevant field trip will create opportunities for STEM faculty to visit K-12 classes and talk about their research in age-appropriate and interesting ways, so that young people can see concrete examples of what scientists and engineers do and meet real scientists and engineers, especially women. They argue that these *female* scientists, engineers, and graduate students from STEM programs will be of great encouragement to the students given that female students are positively influenced by female role models in STEM.

Supporting this Dasputa and Stout (2014) opined that STEM departments should support programs that help foster a sense of belonging among women in STEM, and encourage female students to attend diversity conferences and professional society meetings such as Society of Women in Engineering, which invest in students' success.

This result also agrees with Mavriplis et al., (2005) who are of the view that professional societies and universities could provide structured professional development opportunities, so women can anticipate some of the barriers hindering them from participating in STEM, plan how to navigate them, and predict important decision points. They went further to suggest that career mentoring workshops should be organized to provide support at professional society meetings.

Table 3 shows no significant difference in the mean scores of male and female STEM teachers on the strategies for promoting gender equality in STEM for sustainable development. Both male and female teachers have the same opinion on the issue being discussed implying that gender has no effect.

Conclusion

Despite the fact that enabling policy environment and many initiatives are being implemented to promote women's and girl's education in STEM subjects/disciplines, a number of social-cultural and institutional barriers continue to prevent girls and young women from attending schools and universities and from performing equally to their male classmates (UNESCO, 2010). For sustainable development of Nigeria, there is a need for promoting gender equality in STEM.

Recommendations

Based on the findings, the following recommendations are made;

1. STEM teachers teaching girls/women studying STEM related subjects in the secondary schools and universities should expose these students to female STEM experts and peers for encouragement.

2. STEM teachers should take STEM students (both boys and girls) to science museums for the teaching of these STEM subjects/courses to be real.
3. STEM teachers should organize after-school classroom-based hands-on STEM workshops involving construction and test of real-life engineering subsystems in a relaxed and non-evaluative atmosphere.
4. STEM teachers should organize summer day camp involving exposure to hands-on STEM projects for STEM students (both boys and girls).
5. The Ministry of Education should organize mentoring Program featuring opportunities to meet and speak with practicing female and minority STEM professionals.
6. The Federal Government should organize Parent/guardian workshops designed to inform and empower parents in their efforts to support their children's success in STEM.

References

Barker, L. J. & Aspray, W. (2006). The State of Research on Girls and IT. J. M. Cohoon and W. Aspray (eds), *Women and Information Technology*: *Research on Underrepresentation. London, The MIT Press, pp. 3-54.*

Danmole, B. T. (2011). Emerging issues on the universal basic education curriculum in Nigeria: Implication for the science and technology component. *Pakistan Journal of Social Sciences. 8(1) pp 62-68. Retrieved on 7/4/11 from www.madewelljournals.com*

Dantani, I. W. & Baba, G. K. (2011). Science, Technology, Engineering and Mathematics Education: Nigeria in the Emerging World order and Militating Issues for Development. *Proceedings of the 52nd Annual Conference of the Science Teachers Association of Nigeria (STAN) pp.23-29.*

Dasgupta, N. (2011). In-group experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychological Inquiry*, *22*, 231-246.

Dasgupta, N., Hunsinger, M., & Scircle, M. (2014). Stereotype inoculation in adolescence: The effect of teacher gender on adolescents' academic self-concept and beliefs about science. *Unpublished manuscript, University of Massachusetts Am-herst.*

Dasgupta, N & Stout J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the Tide and Broadening Participation in STEM Careers. *Policy Insights from the Behavioral and Brain Sciences, 1(1) 21– 29.*

European Bank for Reconstruction and Development (EBRD) (2016). Report from the document of the European Bank for Reconstruction and Development (EBRD). 2016.

Lopez-Claros, Augustino and Zahidi, Saadia, (2007). Women's Empowerment: Measuring the Global Gender Gap, World Economic Forum.

Mavriplis, C., Heller, R., Sorensen, C., & Snyder, H. D. (2005). The FORWARD to professorship workshop. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exposition, American Society for Engineering Education.*

National Science Foundation. (2016). Graduate Research Programme. https://www.nsfgrfp.org/

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using in-group experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM*). Journal of Personality and Social Psychology, 100, 255-270.*

Stout, J. G., Ito, T. A., Finkelstein, N. D., & Pollock, S. J. (2013). How women's endorsement of gendered science stereotypes contributes to the gender gap in STEM participation. *Presentation at the annual meeting of the Society for Personality and Social Psychology, New Orleans, LA.*

Ugwuada, A. O. (2011). Strategies for reforming science, technology, engineering and mathematics (STEM) teaching and learning in schools. *Proceedings of the 52nd Annual Conference of the Science Teachers Association of Nigeria (STAN) pp.60-65.*

UNESCO (2006). International Implementation Scheme for the Decade in Brief: *http://portal.unesco.org/education/en/ev.php-URL_ID=23280&URL_DO=DO_ TOPIC&URL_SECTION=201.html.*

UNESCO (2010). Increasing Women's Participation in Science, Mathematics and Technology Education and Employment in Africa. *Expert group meeting Gender, science and technology*

UNESCO (2016). Incheon Declaration. Education 2030*:* Towards Inclusive and Equitable Quality Education and Lifelong Learning for All. *Paris, UNESCO.*

United Nations (2014). Sustaining Human Progress: Reducing Vulnerabilities and Building Resilience. *Human Development Report 2014.*