DETERMINANTS OF GIRL CHILD EDUCATION IN STEM: DOES GENDER MAIN-STREAMING MATTER?

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ABSTRACT

Girls and women are still under-represented in STEM education in all level of education system in South Africa. The under-representation of female gender in science education may be attributed largely to school and parental factors. Therefore, this study deep dive into analysing the school and parental factors influencing the participation of female students in secondary schools in STEM career in UGU district municipality of KwaZulu-Natal Province, South Africa. The study sampled 110 students (45 males and 65 females) in four secondary schools in the study location. A descriptive research design was employed to address the research problem in the study area. A questionnaire design was adopted to elicit information from the respondents. A set of analytical tools such as mean and t-test statistics were used to analyse the datasets collected from the field. It turns out that school and parental factors constitute significant factors influencing female students' participation in STEM education in the sampled secondary schools across the study location. The research concluded that socio-cultural factors, gender biased curriculum material and inadequate employment of female teachers as role models for female students constitute the school and parental factors causing low enrolment of female students in STEM education in the study area. Based on the result from this study findings, the research recommends that STEM education professionals such as teachers in secondary schools and lecturers in the universities should organize awareness programs for female students, parents and the general public on how to improve female participation in STEM education program under the watch of stakeholder, non-governmental organization as well as government. Government should also employ more female education science teachers who studied STEM courses to serve as role models to female students in all the secondary schools across the study area.

Keywords*:* STEM Education, Females' interest in STEM, Gender Main-Streaming

I. INTRODUCTION

Bringing more girls and women into science, technology, engineering and mathematics, STEM, is often highlighted as an aim in education and industry. A constantly growing body of research on engagement is driven by equity concerns caused by the unbalanced gender distribution in STEM. However, more girls are in school today than ever before, but they do not always have the same opportunities as boys to complete and benefit from an education of their choice. Too many girls and women are held back by biases, social norms and expectations influencing the quality of the education they receive and the subjects they study (United Nations Educational, Scientific and Cultural Organization, [UNESCO], 2022). They are particularly under-represented in science, technology, engineering and mathematics (STEM) education, and consequently, in STEM careers UNESCO (2024). Globally, UNESCO (2019) recommended equal proportions to the ratio of boys to girls in STEM career path but the ratio of boys to girls stood at 73% to 27%

in 2023 in South Africa. This gender disparity is alarming, especially as STEM careers are often referred to as the jobs of the future, driving innovation, social wellbeing, inclusive growth and sustainable development. STEM education is an integrated field of study which considers both the subject matter of science disciplines such as chemistry, physics, mathematics etc. as well as the processes involved in the learning and teaching of science. According to Fagbemi and Ariwodola (2020), science students understand the nature and processes of science, and appreciates the sociological, philosophical and epistemological aspects of the scientific enterprise. This understanding is extended to technology. Reference to science education is almost synonymous with Science, Technology, Engineering and Mathematics (STEM) (Gabriel & Samuel, 2020). Science Education is vital and play a critical role in national development especially in African countries. According to Caleb and Ezeofor (2018), a country with higher proportions of graduates in Science Technology, Engineering and Mathematics (STEM), tend to grow faster in terms of socio-economic development than in other discipline. No citizen therefore deserves exclusion or limitations in being scientifically literate. Nigeria, like other African nations has a dire need to rise up to ensure equality in participation of both its male and female citizens in science education.

Unfortunately, Women under-representation in science, Technology, Engineering and Mathematics (STEM), has been documented worldwide. The low participation of women in the science field has been a concern of many governments of the world (United Nation Development Programme [UNDP], 2024). Social cries have been heard around the globe that women are under -represented in the field of Science and Engineering in higher education (Alarina& Owolabi 2020; United Nations International Children's Emergency Fund [UNICEF], 2023). Low participation of females in the sciences cut across every level of education. According to Wiley and Fagbemi (2019), it is obvious to find that women are underrepresented in Science, Technology, Engineering and Mathematics (STEM) related industrial and academic leading positions. These untapped fully trained and potential women, who could be interested to pursue STEM opt out and probably change their careers because of obstacles emanating either from sociological or psychological ground (Bello, Faisal & Tahir, 2019). Women and girls have not been utilized to their full potentials. The world misses the exploitation of the potential female scientific talents especially when considering their contribution to science related field advancement (Smith & Monday, 2019).

However, in 2023, the European countries had 40 percent of women in Natural Sciences and Japan had only 20 percent of women in the same field (UNESCO, 2024). In the same year, according to UNESCO (2024), women's participation in science Education and Technology industries was as follow; Europe had 15 percent, the United State of America (USA) had 19 percent while South Africa had only 6 percent. In the USA, only a quarter of the workforce with a background in STEM are women (Ashiru&Igwe, 2023). Estimate indicate that fully 90 percent of future jobs will require some forms of Information and Communication Technology (ICT) skills and the fastest growing job categories are related to STEM (UNESCO, 2024). Nonetheless, in 2023, only 15 percent of women were full professors in the European Union countries and rarely few women were found in engineering fields (UNESCO, 2024). In South Africa, while the government has in recent years focused attention on straightening national capacity in STEM, a key recommendation and objective of its vision is envisage in the sustainable development goals plan for economic transformation, gender equity in science education has not been fully specified

and has not initiated national policies toward this goal. (UNESCO, 2022). Female participation in science received mention in South Africa's most recent Innovation and Technology Policy, but no specific objective and strategies have been developed towards achieving the objectives (Ndache&Stober, 2019). This could partly be attributed to the lack of awareness of the importance of gender equity in science related courses in Nigerian educational system. Education for all is understood in the basis of equal access to education, but this is not enough. Equality and future development of Ugu district municipality of KwaZulu-Natal Province, South Africa society is dependent on the provision of high-quality Science and Technology education for male and female genders in the society (Abraham & Thomas, 2020). According to Abdullahi and Fagae (2021), the career impediment for women deprives societies of their scarce Human Resources (HRs), and this is detrimental to the global labor force, competiveness and development. Nevertheless, girls and women need an education that goes beyond literacy and numeracy, which will equip them with the tools to equally and actively participate in solving the complex challenges that our society are facing today. With science and technology accelerating, our economies will rapidly change to face the effects of the recent national economic crises. Meanwhile, Girls' and women are still under-represented in science education in all level of education system in Ugu district municipality of KwaZulu-Natal Province, South Africa. The under-representation of female gender in science education can be attributed largely to the construction of feminine identities, ideologies of domesticity and gender stereotype. According to UNICEF (2023), 4 in 10 South African women encounter some conflicting experiences and obstacles that have prevented many of them from entering, staying and excelling in STEM careers.

Adebowale and Bello (2021) also reported that gender differentials in enrolment and achievement in higher education is invariably rooted in inequality at the primary and secondary levels where the real sorting out of university bound students take place. Female participation and interest in STEM diminishes as they move up in the educational ladder towards the university level due to a variety of factors that are primarily rooted in their religious and cultural beliefs surrounding the role of women in the society. Relatively, some other factors that have been identified as contributory to the underrepresentation of female gender in STEM include; lack of support from education policy makers, different socialization pattern for boys and girls at early stage of life, early marriage and teacher attitude to girls. Nathaniel and Jonah (2018) also noted that factors affecting girl-child and women in science related fields of study are poor societal perception, poor entry level, lack of recognition and discrimination against graduates of STEM education. Onifade and Ogunyemi (2019) equally reported that some of the factors include government and parental lukewarm attitude towards STEM, the negative attitude developed by the students themselves towards STEM subjects, the stereotype concept of women themselves, cultural influence, psychological factors and shortage of laboratories and teachers.

Consequently, these factors have been so much associated as the main sources of the problem; previous literature concentrated at the secondary educational level. Most scholars also focus on factors that hinder teaching and learning in science related subjects in primary school in general but they do not specifically point out the parental involvement in the training of the female gender which can constitute a bridge for girl –child participation in STEM education. The present study attempts to identify the factors affecting participation of female in science education program in some selected secondary schools in Ugu district municipality of KwaZulu-

Natal- Province, South Africa. This study therefore proposes that female students in secondary school desire in pursuing careers in STEM education could be explained by their schools and parental factors. Policymakers can reverse the waning interest in STEM education among South African secondary school students by creating educationally oriented policies based on an understanding of these causes. Hence, the objective of this research is to investigate the school and parental factors influencing girl child in choosing career path in STEM in some selected secondary schools in KwaZulu-Natal Province, South Africa's Ugu district municipality.
The study is organized as follows: the research methodology and literature review are presented in the next section; the empirical results and their discussion are presented in part four; conclusion, and recommendation are presented in sections five, six, and seven, respectively.

RESEARCH QUESTIONS

i. What are the school factors influencing the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa?
ii. What are the parental factors affecting the participation of female students in secondary schoolin STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa?

II. LITERATURE REVIEW

Several studies at domestic and international level have explored the determinants of female career choice in STEM education. For instance, in a chapter discussing gender and its implications on STEM education, Paechter and Michael (2020) point out that in education, the feminine is generally seen as subordinated to the masculine, which inevitably alienates and creates a sense of non-belonging for girls interested in male-dominated areas such as technology and engineering education. The influence of perceptions of the feminine and the masculine on STEM participation has also been studied by researchers such as Archer et al. (2020), Berner (2018), Barton et al. (2018), Faulkner (2021), Francis (2018), Mellström (2019) and Ottemo et al. (2020), confirming this as a complex area. Salas-Morera et al. (2019) conducted a survey in Spain on males and females in upper secondary school, the first year of engineering degrees and the first year of science degrees. The results show that although girls who participated in the survey saw engineering professions as highly valued, they still declared that these professions were not for women. Girls who are relatively uninterested in STEM-related school subjects are also more likely to believe that these subjects constitute a male domain, as evidenced in a Croatian study (Blažev et al., 2018).

In Finland, Autio and Augusta (2021) concluded that making motivated behavioural choices towards studying or working in technical fields is a complicated process, particularly for women. In another development, Engström and Boris (2019) reported that Swedish female engineering students in higher education who do go on to graduate have experiences and resources such as "well-educated parents, positive attitudes to the engineer students' traditions, and a positive view of the engineering profession" This is also recognizable in Lloyd et al. (2018) when studying Australian 8 to 18-year-old pupils. The authors found that pupils interested in STEM were typically high achieving, and over 90% of their guardians aspired for them to attend university. Stereotypes about girls in relation to technology may also deter girls from pursuing their interests in STEM and induce less positive attitudes (Brownlow et al. , 2020; Cheryan et al. , 2019

&Sultan et al. , 2019). When technology is constructed as a male domain and comprised of male attributes, this tends to produce negative self-images among girls (Godec et al. , 2020; Kessels, 2018; Sanders, 2019). There is also a corresponding gender difference in interest in the technological and engineering fields between girls and women on the one hand and boys and men on the other. This interest difference begins as early as elementary school, with girls reporting less interest and less confidence in their abilities than boys, which may affect future educational choices (Archer &MacRae, 2020; Archer et al. , 2018; Ardies et al. , 2019; Ertl et al. , 2020;Jidesjö, 2023; Hand et al. , 2018; Rooke, 2019; Varney et al. , 2022). According to Archer et al. (2020) and UNESCO (2024), most interventions focus on students aged fourteen and above, even though career aspirations have often already formed by the age of thirteen. After this, it is increasingly difficult to interest students in the STEM field (Lindahl, 2018).

Further, Mqadi (2023a) adopted mixed research methods and descriptive statistics to examine the effect of mentoring program on the teachers' teaching learners with learning difficulties in South Korea. The study found a significant relationship between teachers' mentoring and the teaching skills of teachers teaching the difficult to learn pupils. Also, Mqadi (2023b) equally employed a quasi-experimental non-randomized research design involving pre-test and post-test with a control group and ANCOVA to investigate the impact of teachers' mentoring programme on teachers' classroom practices and pupils learning outcomes in KwaZulu-Natal Province, South Africa. The study concluded that teachers' mentoring activities has significant impacts on classroom practices of teachers and pupils' learning outcomes in the sampled primary schools in Ugu district municipality, KwaZulu-Natal Province, South Africa. Also, Mqadi (2024) equally employed post-test control group research design to investigate the efficacy of STEM mentoring programs on the students' interest towards STEM in some selected secondary schools in in Ugu District Municipality of KwaZulu-Natal Province, South Africa. Specifically, the study analyses the extent to which secondary school students developed interest towards STEM subjects. The research found that the level of all three aspects of interest towards STEM are moderately high and high with the mean scores between 3.5 to 4.3 which are within the threshold of 3. 0 estimated for this research. The study also found that the students' level of interest towards science is 'high' for both group and gender. Meanwhile, the level of interest towards mathematics indicated a different level in both group and gender. The study concluded that boys in treatment group shows moderate level of interest towards mathematics compared to the boys in control group with high level of interest towards mathematics while girls in the treatment group indicated high level of interest towards mathematics compared to the girls in control group.

In summary, previous studies indicate that although results vary, all-girl camps in STEM fields may positively affect the participating girls' motivation, interest and sense of belonging, especially in technology and engineering, these studies concentrated major on students in tertiary institutions and primary schools without necessarily looking at the issues from secondary or high school perspective which constitute the foundational base of STEM career pathways. Therefore, based on this premises, this study attempts to close this knowledge by investigating the factors affecting participation of female students in science education program in some selected secondary schools in Ugu district municipality of KwaZulu-Natal Province, South Africa.

III. METHODOLOGY

Descriptive research design was adopted to carry out this study. Descriptive research design is a systematic manner of gathering data and describing the characteristic features and facts about a giving population (Anikura& Nwosu, 2018). The population of the study comprised 110 students (45 males and 65 females) from four selected secondary schools in Ugu district municipality of KwaZulu-Natal Province, South Africa. The survey instrument for used for eliciting information from respondents was divided into two sections. Sections one and two have 21 questions each making up a total of 42 items in the questionnaire. The questionnaire is on four point Likert scale of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) with a corresponding weight of 4, 3, 2, and 1 respectively. The reliability of the instrument was carried out using Cronbach Alpha which yielded the reliability index of 0. 86. This indicates that the survey instrument is reliable. The questionnaires yielded a hundred percent return rate. Mean and Standard Deviation were used to analysed the datasets collected from the field. The hypotheses were tested using t-test at 0. 05 level of significance. However, the decision point for the mean was set at 2. 50. This imply that any response with 2. 50 and above is regarded as agreed, while mean response below 2. 50 is regarded as disagreed.

IV. DATA PRESENTATION AND DISCUSSION OF RESULTS

Research Question 1: What are the school factors influencing the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa?

Table 1: Analysis of the school factors influencing the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa

S/N	Variables	Mean	S. D	Decision Rule	Mean	S. D	Decision Rule
1	Inadequate teachers as role model	3. 51	1. 00	Agreed	3. 13	1. 04	Agreed
2	Peer group influence	3. 39	0. 82	Agreed	2. 60	1. 16	Agreed
3	Long hours of instructions	3. 55	0. 70	Agreed	3. 47	0. 51	Agreed
4	Lack of female interest in STEM education	3. 40	1. 04	Agreed	3,03	1. 10	Agreed
5	Inflexible selection and entry requirement	3. 32	0. 63	Agreed	2. 77	1. 10	Agreed
6	Gender bias curriculum materials	3. 18	0. 75	Agreed	2. 83	1. 09	Agreed
7	Inadequate human facility	3. 47	1. 01	Agreed	3. 17	1. 09	Agreed

8	Masculine image of science projected in textbook and media	3. 04	0. 94	Agreed	3. 00	1. 08	Agreed
9	Lack of prior knowledge of the importance of STEM education	2. 46	1. 16	Agreed	3. 03	1. 08	Agreed
10	Inadequate physical facility	3. 72	0. 70	Agreed	3. 03	1. 08	Agreed
11	Poor relationship between teachers and students	3. 29	0. 99	Agreed	3. 37	1. 00	Agreed
12	Assumptions that science education is difficult	3. 07	1. 52	Agreed	3. 00	1. 23	Agreed
13	Lack of awareness on the importance of science education	3. 51	0. 76	Agreed	3. 27	1. 08	Agreed
		3. 38	0. 32	3. 00		0. 38	

Source: Author's Computation (2024)

Research Question 2: What are the parental factors affecting the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa?

Table 2: Analysis of the parental factors affecting the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa

S/N	Variables	Mean	S. D	Decision Rule	Mean	S. D	Decision Rule
14	Domestic chores burden on female gender	3. 46	1. 12	Agreed	3. 07	1. 09	Agreed
15	poor parental perception of science education	3. 09	0. 01	Agreed	2. 89	1. 16	Agreed
16	pregnancy and child rearing	3. 56	0. 13	Agreed	2. 69	1. 10	Agreed
17	parents' consent on early marriage	3. 12	0. 89	Agreed	3. 45	1. 12	Agreed
18	Parents occupation	3. 00	0. 14	Agreed	2. 90	1. 00	Agreed
19	poor residential	3. 13	0. 55	Agreed	2. 87	1. 54	Agreed

	environment						
20	large family size	3. 11	0. 39	Agreed	2. 67	1. 34	Agreed
21	Parents' level of education	3. 03	0. 46	Agreed	2. 98	1. 12	Agreed
21	Parents' income level	3. 15	0. 69	Agreed	3. 67	0. 98	Agreed
		3. 89	0. 68	3. 50		0. 65	

Source: Author's Computation (2024)

Table 3: T-test analysis from mean ratings of the school factors influencing the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa

Gender	N	$\bar{X}$	SD	Sig	t-cal	t-tab	df
Boys	45	3. 28	. 56	0. 05	0. 98	0. 47	135
Girls	65	0. 32	. 59				

**Variables are significant at 5%*

Table 3 illustrates, that the calculated t-value of 0. 98 is greater than t-critical value of 0. 47 at 135 degree of freedom and 0. 05 level of significance. Therefore, the implication of this finding is that school factors responsible for low participation of female students in STEM education are significantly being affected negatively by gender factor in schools.

Table 4: Summary of t-test analysis from mean rating of parental factors affecting the participation of female students in secondary schools in STEM career in Ugu district municipality of KwaZulu-Natal Province, South Africa?

Gender	N	$\bar{X}$	SD	Sig	t-cal	t-tab	df
Boys	45	2. 17	. 56	0. 05	2. 78	1. 13	135
Girls	65	2. 48	. 59				

**Variables are significant at 5%*
Source: Author's Computation (2024)

Table 4 depicts that the calculated t value of 2. 78 is greater than t-critical value of 1. 13 at 135 degree of freedom and 0. 05 level of significance. Therefore, parental factors responsible for low participation of female in science education program are significant at 5%. The implication of this finding is that parental factors responsible for low participation of female students in science education are being affected negatively by gender factor in schools.

DISCUSSIONS OF FINDINGS

This research revealed that the following school factors influence female students' participation in science education program in secondary school in Ugu district municipality of KwaZulu-Natal Province, South Africa. These factors are: inadequate female lecturers as role model; gender biased curriculum materials; inadequate human facilities; masculine image projected in textbook and media; assumptions that science education is a very difficult area; and lack of creating awareness on the importance of science education. The result of this finding is in line with the previous studies conducted by Aladesanmi and Ojokuku (2018), Damilare and Adekunle (2019), Ogala and Opara (2020). In addition, the study also illustrates that the following family factors influence female students' participation in science education program in secondary school in Ugu district municipality of KwaZulu-Natal Province, South Africa. These factors are: parents' level of education; house chores burden on female gender; poor residential environment; parents' occupation and income; parents' consent on early marriage, poor parental perception of science education; pregnancy and child rearing; large family size. This result corroborate the studies conducted by Alagemo and Alarina (2018), Wiley and Adegboyega (2019) as well as Maurice and Alade (2020). Also, the study found that the school and parental factors influencing the participation of female students' career in STEM education are all significant.

CONCLUSION AND RECOMMENDATIONS

From the findings, it can be concluded that school and parental factors had significant influence on female students' participation in science education program in Ugu district municipality of KwaZulu-Natal Province, South Africa. Based on the results from the study findings, this research suggests that STEM education professionals such as teachers in the secondary schools and lecturers in the universities should organize awareness programs for girls, parents and the general public on how to improve female participation in science education program. Government on the other hand should employ more female education teachers who study STEM courses to serve as role models to female students.

Further, science education curriculum should be made to be free from gender biased. The general public should be made to change their perception and attitude towards science education program. Government should make a provision for employment of female science education graduates immediately after study. Likewise, provision of scholarship to the best female students in STEM education to study abroad should be encouraged.

Parents should encourage their female children to study science education. House-chores should not be left for female alone. Early marriage should be discouraged by parents and they should try and know their children's peers. Generally, child care facilities should be provided for nursing mothers in educational institutions.

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