Gender Lens in STEM Education: General Overview of Access, Distribution, and Disparities

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Abstract

All educational levels in Ghana have seen an increase in student enrollment over time. Students' enrollment in STEM programs continues to lag behind that of the arts and humanities, even with this increase. In addition, women lag behind men in STEM programs. Utilizing archival records from multiple sources, the study provided insight into Ghana's STEM education inequalities. Owing to FCUBE and free SHS, gender equality has been achieved at the JHS and SHS level. In spite of this, there are gender differences in STEM education at the higher level. The fundamental cause is that financial aid, the WASSCE pass rate, and other variables affect higher education access and continuation. The study recommends that unless gender sensitive and not gender target measures are put in place to bridge the disparities, differences in STEM will continue.

Introduction

The United Nations' 2030 Agenda for Sustainable Development, which outlines a universal framework with 17 objectives and 169 targets, was accepted by member states in 2015 (African Academy of Sciences (AAS) (2020). Implementing science-related concepts in real-world contexts is a crucial step towards realizing these lofty objectives in all nations. The 169 aims and 17 goals are all meant to better human activities and the ecosystem, but they cannot be accomplished in isolation without the rigorous use of science and technology. Unfortunately, most developing nations have neglected to include girls and women and have not made the most of the idea of all-inclusive affairs.

Goal 5 of the 17 focuses on the importance of achieving gender equality and the empowerment of women and girls. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), (2017), this goal places even more emphasis on the abolition of all forms of discrimination against women and girls, gender-based violence and early marriages, universal access to services related to sexual and reproductive health, and the urgent need for women to participate in decision-making at all levels. Once more, the Africa Union's (AU) agenda 2063 has made clear how urgently girls and women must be enrolled in STEM fields (Africa Union, 2015). The aforementioned UN and AU programs aim to close the gender gap in STEM fields. Furthermore, if only one excelled in science and mathematics, Crawford and Cribb (2013) claimed that this would be a strong predictor of better incomes.

Though it appears that many facets of gender awareness and application have been overlooked, gender is the

most talked subject across regions and organizations. While many nations and organizations still implement gender rules, many of them have proven ineffective. Gender is a broad term with several definitions. Women activists first used the word in the 1970s (Beniamino & Heise, 2019). The nature of the work, duties, compensation, possibilities for training, evaluation, hiring, and many other factors are influenced by gender. According to Anyidoho (2020), gender is the process of performance rather than the result.

Men outweigh women worldwide in all STEM-related fields or categories (students, teachers, researchers, and workers). In other words, women are underrepresented in STEM areas; but, according to the Network of African Science Academies (NASAC), 2017—the situation is worse in Africa. The great difficulty of catching up to men and boys is faced by women and girls. The problem of fewer women in science having limited access to jobs is a serious concern. Women continue to make up a minority of workers in STEM disciplines worldwide, despite advances and increased representation of women in a number of fields (AAS, 2020). This tendency is concerning, and it is particularly pronounced in Africa.

Disparities were found in UNESCO data on female graduates, PhD holders, and scientists. At the PhD level, male graduates outnumber female graduates by 57% to 53% (UNESCO, 2015). Men made up 72% of researchers, which is where the disparity grows (UNESCO, 2015). UNESCO (2015) revealed the proportion of women in various nations. The percentage of women was 49% in Southeast Europe, 44% in the Caribbean, 44% in Central Asia, and 44% in Latin America. Sub-Saharan Africa accounted for 30% of the female participation, followed by the Arab States (37%), the European Union (33%) and the European Free Trade Association (34%). While countries in Africa like Namibia and South Africa are extremely close to achieving gender equality, other countries like Malaysia, the Philippines, and Thailand have already attained gender parity.

Nonetheless, the number of women who pursue careers in scientific research continues to decline at a rapid rate (AAS, 2020). Data from a few affluent nations also show a low percentage of female researchers. In France, Germany, and the Netherlands, for instance, one in four researchers is a woman. Japan (15%) and the Republic of Korea (18%) have even lower percentages. While countries in Africa like Namibia and South Africa are extremely close to achieving sex equality, other countries like Malaysia, the Philippines, and Thailand have already attained gender parity. Of all the members of the Organization for Economic Co-operation and Development, Japan has the lowest percentage of female researchers. In Ghana, the percentage of women enrolled in postsecondary education has improved over time, from 5.15% in 2008 to 13.37% in 2016, more than doubling in the last eight years. Nevertheless, the ratio of women to males in higher education still lags significantly. As a matter of fact, women made up 12.70% of the population in 2014, compared to men's 19.14% (UNESCO, 2018).

Even Senegal, the nation with the least amount of adult female tutoring over the past 50 years, has seen a marked improvement for females. The United Arab Emirates, the country with the largest increase in female tutoring, began at the low degree of 0.9 years stretches of tutoring for the average female and shot to 10 years by 2010. Sub-Saharan Africa and South Asia had the lowest percentages of schooled females in 1960. Furthermore, these areas saw the smallest absolute increases in female education, with increases of less than four years apiece.

Furthermore, those are the only two areas in which a year's increase in male education during that period was not accompanied by a year's increase in female education (Evans et al., 2019).

While females' schooling expanded greatly all throughout the world somewhere in the range of 1960 and 2010, the gender gap in education fulfillment perseveres in numerous nations. Every country in Europe and Central Asia experienced a shift in the gender disparity for women. Gender disparities decreased in every country in East Asia and the Pacific, with the exception of two (Papua New Guinea and Cambodia), and three countries in Latin America and the Caribbean (Cuba, Guatemala, and Haiti) reported a similar trend. According to Evans et al. (2019), the difference in Sub-Saharan Africa shrank from -0.72 years in 1960 to -1.22 years in 1985 before beginning to improve and reaching -0.90 years by 2010.

The United Nations Conference on Trade and Development (UNCTAD) (2011) states that one of the ways the Government of Ghana (GoG) plans to enhance and grow the nation's economy in the coming ten years is through the efficient application of science, technology, and innovation (STI).According to UNCTAD (2011), Ghana has not effectively and fully used STI to assist economic development, and more significantly, there are no supporting policies and initiatives in place. Thus, it is clear that the published policies and the actual policies being implemented by STI programs in Ghana do not coincide. The fundamental reasons for the discrepancy between implemented policies and actual progress are attributed to inadequate planning, a shortage of infrastructure, supplies, and resources (UNCTAD, 2011; Rose et al., 2019).

According to Quansah et al. (2020), gender influences both topic preference and recruitment in postsecondary education. To put it another way, there are significant differences in the proportion of men to women working in STEM subjects in Ghana's higher education institutions.In terms of gender-specific norms and roles, educational barriers, gender stereotyping, power dynamics at work, and biases in decision-making processes, women encounter a great deal of cultural and gender discrimination (Amposah & Mohammed, 2019). Furthermore, biases exist in positions, the division of labor, and the rewards and values (social, economic, and cultural) associated with different laborers. This typically affects women's self-confidence and self-esteem. According to Amposah and Mohammed (2019), these kinds of cultural biases affect how students are taught and what courses they choose to study in school. The proportion of women enrolling to finish their education and find work in STEM sectors has significantly decreased as a result (NASAC, 2017).

There exist available components important for efficient and effective STI system in Ghana. These comprise 153 authorized postsecondary institutions (MoE, 2019), new STEM schools, a number of research institutes, a number of technology-related policies, and numerous other establishments. Therefore, this is a solid foundation upon which to build; yet, STEM progress has not followed suit. According to the World Bank (2019), men and boys continue to have greater access to education in Ghana, with women making up fewer than 25% of STEM degree holders (Global Education Monitoring Team (GEMT), 2018). Despite the fact that men predominate in the STEM fields in Ghana, these fields nevertheless fall behind in terms of economic emancipation (Amposah & Mohammed, 2019). In Ghana, not enough has been done to use STEM for female development, and disparities still exist in the tertiary education system despite the availability of STEM structures, numerous interventions,

and incentives in the form of scholarships and other support intended to encourage women to participate in STEM. Data available indicates that there are fewer women in STEM professions and research, and that few female students actually enroll in STEM-related university programs. The main objective of the study was to assess Gender lens in STEM education: General Overview on access, distribution and disparities in Ghana**.** Two research objectives are addressed in this study:

1. To explore the general access, enrollment and equity within the Ghana education system.
2. To explore factors accounting for STEM gender disparities.

Methodology

Using data from *Educational Sector Performance (2010, 2016, 2018,) National Council for Tertiary Education 2018, National Accreditation Board, UNESCO***,** *National Gender Policy* (NGP, 2015)*;* the *National Science and Technology Policy* (2010); the *Education Strategic Plan 2010–2020*; the *Science Mathematics and Technology Education* (STME) initiative (1987) and *2010 Ghana Population and House Census*, the author provide a broad descriptive and critical analysis of STEM education. The authors provide broad anatomy of disparity base analysis of basic, second cycle institutions and tertiary education on access, enrollment and equity, followed by completion rates, gender disparity in tertiary education, program disparity in tertiary institutions, gender-based disparity in financial aid, gender-based disparity in mode of enrolment by type of institution and government policies and universities strategic plans. The authors utilize Lorenz curve concepts to provide the levels of gender disparities in basic and second cycle education that leads to disparities in STEM education at the tertiary level in Ghana.

Results and Discussion

General Access, Enrollment and Equity

Basic to Second Cycle Institutions

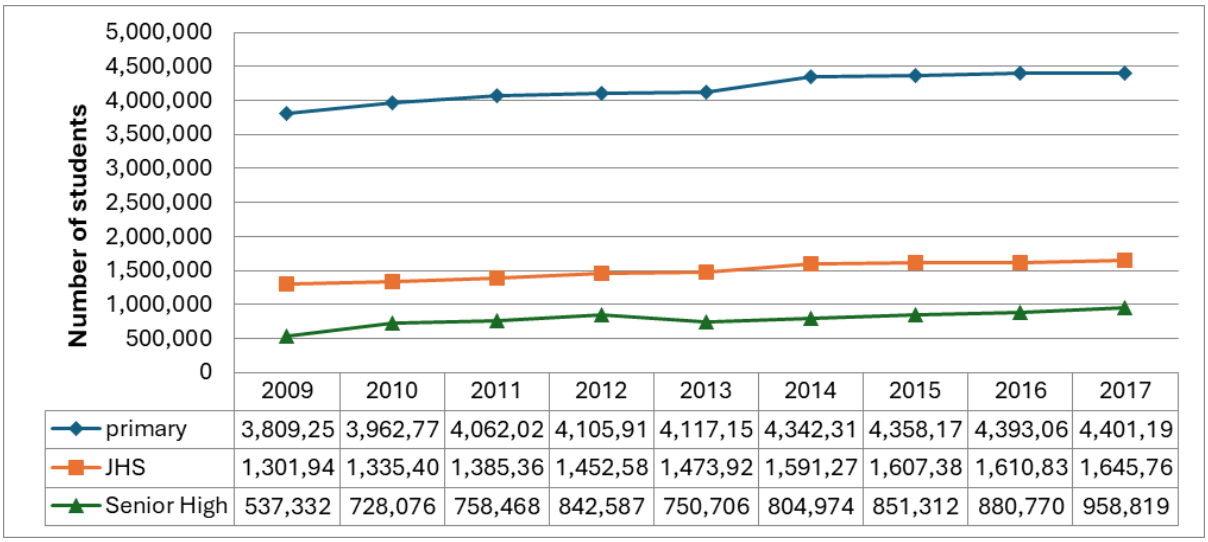
A vital component of a country's development is formal education. It is a way to enable human resources to investigate and make use of the natural resources for the political, economic, and socio cultural growth of the country. Indeed, democracy collapses and behavioral change is hampered in the absence of extensive formal education. According to Bailey and Graves (2016), education serves as a "social equalizer," which is one of its primary purposes. This indicates that education can help kids break free from the cycle of poverty in their homes, lessen conflict and violence, and boost girls' wages by delaying marriage. Children from a variety of circumstances can gain the transformative skills they will need as adults by having access to school. Studies conducted throughout the years have demonstrated that many countries do not fully accomplish school-age children's access and enrollment in educational institutions. It gets worse for girls from lower-class families. In most parts of the world, there are disparities in gender and access to, enrollment in, and completion rates of educational systems at all levels. It should be mentioned that the 1990 UNESCO world conference on "Education for all," which was held in Jomtien, Thailand, launched the idea that all children should have access to a basic education. The summit charged leaders to make all effort to fulfill EFA goals especially basic education for every child irrespective of gender, and to also reduce adult illiteracy by 2000. The earlier EFA

goals were subsequently reaffirmed at a number of conferences, which ultimately resulted in the 2002 announcement of the Millennium Development Goals (MDGs). The UNDP (2000) set 2015 as the deadline for achieving Goals 2 and 3, which center on gender equality and empowerment as well as universal primary education. This marked the achievement of the MDGs reviewed's gender and education-related goals. For example, according to UN (2015), the net enrollment in elementary schools increased from 83% in 2000 to 91% in 2015. In addition, the literacy rate for young people (15–24 years old) increased significantly from 83% in 1990 to 89% in 2010. Thus, this indicates that the number of primary school-age children who are not in school has decreased. Even while more children are able to attend school, the quality of that education has long been a topic of discussion. Numerous assessments indicate that instruction is of low quality in many parts of the world. Basic reading comprehension and sentence recognition have been difficult. For example, research from Tanzania, Kenya, and Uganda showed that third-grade children struggle with sentence comprehension (World Bank, 2018). Once more, Marchetta & Dilly (2019) contended that 75% of third-grade children in rural India were unable to perform a two-digit subtraction. The Sustainable Development Goals (SDGs) were implemented in order to enhance the attainment of the Millennium Development Goals. The fifth objective of the SDGs supports gender equality and the empowerment of women and girls, whereas the fourth goal focuses on inclusive and equitable quality education and lifelong learning opportunities for all.

The Ministry of Education in Ghana is responsible for overseeing policy enactment, planning, and monitoring related to education in the country (MoE, 2012). It works in tandem with Ghana Education Service to oversee primary and secondary education (UNCTAD, 2011). The Ministry of Education is divided into five sections: tertiary education, inclusive and special education, non-formal education, secondary level, and basic education. A managing agency is tasked with overseeing the division's operations in every division. The National Council for higher Education oversees higher education, while GES is in charge of basic and secondary education (pre-tertiary education). The Council for Technical and Vocational Education Training is in charge of TVET, the Special Education Division is in charge of special education, and the Non-Formal Education Division (NFED) is in charge of non-formal education. In addition to them, the National Teaching Council (NTC), the National Council for Curriculum and Assessment (NaCCA), and the National Inspectorate Board (NIB) are dependent bodies in charge of the accountability of the educational system (Marchetta & Dilly, 2019).

Preschool, Primary classes 1-6, and Junior High School forms 1-3 have seen a significant increase in access and enrollment in Ghana. This may be partially attributed to the government and Ministry of Education's commitment to supporting all school-age children in the nation and giving them access to adequate, free, and compulsory basic education (MoE, 2018). Even though basic education is free and required, some children who should be in school are unable to enroll. The basic education sector and senior high level of education have shown a rise in enrolment throughout the years 2009-2017. The number of students enrolled in basic education increased from 3,809,258 in 2009 to 4,401,194 in 2017. The number of students enrolled in junior high school (JHS) climbed from 1,301,940 in 2009 to 1,645,764 in 2017, exhibiting a positive trend in enrollment (Figure 1). Figure 1 also shows a high percentage of students who are unable to advance from elementary to junior high and senior high school. Once more, the data showed that nearly two million elementary school students are not able to go to junior high school. The alarming problem is the rate of loss and the incapacity to enroll over half of

the primary school students in the JHS.



	2009	2010	2011	2012	2013	2014	2015	2016	2017
primary	3,809,25	3,962,77	4,062,02	4,105,91	4,117,15	4,342,31	4,358,17	4,393,06	4,401,19
JHS	1,301,94	1,335,40	1,385,36	1,452,58	1,473,92	1,591,27	1,607,38	1,610,83	1,645,76
Senior High	537,332	728,076	758,468	842,587	750,706	804,974	851,312	880,770	958,819

Figure 1. Enrollment Trend by Level of Education in Ghana

Source: Based on data from Ministry of Education (2015; 2018)

It is noteworthy that, according to the Ghana Statistical Service (GSS) 2015, fertility decreased from 6.4 to 4.2 per woman throughout these years, yet enrollment rose at a startling rate. This indicates that parents tried to educate their kids. It goes without saying that the modest increase in the Total Fertility Rate (TER) over the previous six years—from 4.0 to 4.2 children per woman—means that enrollment in the years to come may even be huge (GSS, 2015).Despite this, Ghana continues to have some of the lowest TFRs in sub-Saharan Africa. Data from the MoE show that enrollment in rural areas is lower than in urban areas, despite the fact that rural women have roughly 1.7 more children than urban women (5.1 against 3.4 children per woman). In terms of elementary school completion rates, girls made up 73% of the total, males 69%, while for JHS, males made up 45% and females 50% (MoE, 2022). Compared to JHS education (47%) and basic education (71%) had better overall completion rates (MoE, 2022). Despite having a high rate of literacy, Marchetta & Dilly (2019) reported that in Ghana, 75 out of 100 students enrolled in elementary school graduate to junior high school. Of these 75, 59 are able to finish JHS, and 41 are able to enroll in SHS. Only 16 percent of students that enroll in pre-school are able to progress to SHS, which is a relatively low percentage. This has been the situation over time, but enrollment is expected to alter when the free SHS and FCUBE are implemented. The net enrolment rate for secondary (senior high) schools was 58.3%, while the net enrolment rate for primary schools was 84.4% (MoE, 2022).

Ghana has seen an improvement in access to education during the past ten years when compared to other bordering African countries since it is one of the few countries in Africa where pre-school is required, however early enrollment is problematic. Even though primary school officially begins at age four, children of primary school age are frequently found still at home due to a shortage of spaces in schools, which frequently results in late enrolment in pre-school. (Marchetta & Dilly, 2019). The primary, junior high, and senior high school levels of education were evaluated using the Gross Enrollment Ratio (GER) and the Net Enrollment Ratio (NER), as

shown in Table 1. The former shows, as a percentage of the age group that officially corresponds to the specified level of education, the total number of children enrolled in a class or school, regardless of age. Conversely, the Net Enrolment Ratio is the total number of kids in a certain age range who are enrolled in a class or school as a percentage of all kids in that age range. Despite an increase in enrolment at the basic level, Table 1 shows that NER and GER increases have not been uniform across all basic education levels. The GER between JHS and SHS has gaps in it. The former shows, as a percentage of the age group that officially corresponds to the specified level of education, the total number of children enrolled in a class or school, regardless of age. Conversely, the Net Enrolment Ratio is the total number of kids in a certain age range who are enrolled in a class or school as a percentage of all kids in that age range. Despite an increase in enrolment at the basic level, Table 1 shows that NER and GER increases have not been uniform across all basic education levels. The GER between JHS and SHS has gaps in it. This shows that as of the 2017–18 academic year, MoE had almost reached parity at the basic level (KG, Primary, and JHS). A similar pattern was observed in impoverished areas. There has been a noticeable improvement at all three levels, but still falling short of the national averages (MoE, 2015; 2018).

Table 1. GER and NER by Level of Education 2009-2017

Year	**GER**				**NER**				**GPI**			
	KG	Primary	JHS	SHS	KG	Primary	JHS	SHS	KG	Primary	JHS	SHS
2009	98%	96%	80%	36.1%	60%	78%	46%	18.5%	0.98	0.96	0.92	0.85
2010	99%	97%	81%	36.5%	64%	82%	46%	24.3%	0.98	0.97	0.92	0.87
2011	114%	105%	82%	37.1%	75%	84%	48%	23.6%	0.98	0.97	0.94	0.87
2012	123%	107%	82%	36.8%	91%	89%	49%	23.6%	1.03	0.99	0.93	0.86
2013	129%	110%	85%	43.9%	83%	91%	49%	21.8%	1.01	0.99	0.95	0.91
2014	124%	111%	88%	45.6%	80%	92%	50%	22.5%	1.04	1	0.96	0.91
2015	115.60%	111.40%	86.80%	49.6%	74.60%	91.10%	50%	25.2%	1.01	1.01	0.97	0.94
2016	112.4	106.2	86.1	50.1%	74.6	89.3	48%	26.5%	1	1.01	0.98	0.96
2017	98%	96%	80%	55.9%	60%	78%	46%	29.2%	1	1	1	0.92

Source: Based on data from Ministry of Education (2015; 2018)

NB: GER = Gross Enrollment Ratio; NER = Net Enrollment Ratio; JHS = Junior High School; SHS = Senior High School; GPI = Gender Parity Index.

While gender equity in basic education has been reached nationally, secondary education does not share this achievement. During the academic year, the secondary level Gender Parity Index (GPI) was 0.92, down from 0.96 in the prior year (2016). Prior to the introduction of free SHS, the expense of a secondary education was nearly GH~ 2000. The impoverished found it difficult to use, which prevented them from enrolling. Low GER in SHS is explained by high school dropout, socioeconomic, institutional, and BECE failings (World Bank, 2011). This is also a significant factor in how pupils move from JHS to SHS 1. As has been shown with the adoption of free SHS, educational attendance, attainment, and other results would gradually increase as the cost of senior high school education in Ghana decreases. Students who perform poorly typically return to school to retake the BECE. BECE remedial was recently launched by GES, giving students the chance to retake the exam

and get admitted. Furthermore, pupils who were not able to enroll under the free SHS for previous years now have the chance to fill out a form and enroll thanks to a recently implemented order. It is believed that GER and NER for SHS will improve under the free SHS policy, resulting in tertiary enrolment increase.

Tertiary Institutions

Bachelor's or equivalent level programs, short-cycle programs (diploma, higher national diploma (HND), or certificate programs), master's or equivalent level programs (postgraduate certificate, postgraduate diploma, and master degrees), and doctoral or equivalent level programs (Doctor of Philosophy (PhD) programs) are among the courses that can be enrolled in postsecondary institutions. Due to rising demand and a lack of new housing developments, academic credentials and residential amenities have an impact on admission to Ghanaian colleges. But enrollment in postsecondary institutions is voluntary. There are 153 accredited tertiary institutions in Ghana, comprising public universities, public specialized/professional colleges, chartered tertiary institutions, technical universities, and public and private colleges of education, are responsible for providing tertiary education, according to available statistics (MoE, 2018). Admission to postsecondary education, particularly undergraduate programs, is contingent upon achieving the highest possible overall score on the WASSCE exam. Individual pupils must receive the required passing scores on the final test in order to advance, especially from secondary school to higher education levels (Kankpi & Graham, 2022). The ability of a candidate to obtain the qualifying grade (Grades A1 to C6) in six subjects (three core subjects, namely English, mathematics, and science or social studies, and any three elective subjects) in the West African Examination Secondary School Certificate Examination (WASSCE) is the prerequisite for admission to post-secondary education. The degree to which pupils' ability to earn the minimal grades necessary in the pertinent subjects determines how far they can advance from senior high school to tertiary or post-secondary education. Regarding the eligibility of students, research have brought attention to the issue and reports from the education sector have indicated that girls' performance in the WASSCE is often low (Associate for Change, 2011; CAMFED, 2012; MOE, 2018). The findings from the Figure below demonstrate how students' scores on the qualifying exam (Grades A1 through C6) fluctuate. In all subjects except mathematics, the scores from 2023 were the best (Figure 2). In the past 12.5% of students in 2006, 10.5% in 2007, 12.9% in 2008, 14.5% in 2009, 26% in 2011, 31% in 2012, 19% in 2013, and 28.1% in 2014 were classified as A1-C6. Wrigley-Asante et al. (2023) conducted a comparison of the WASSCE performance of males and females and found that, overall, the results indicate that, at the senior high school level, males performed better academically than females, while at the tertiary level, females' academic performance appeared to have improved in comparison to males'. According to Efa et al. (2023), female students outperformed male students in optional mathematics in Ghana's central area in every year but 2021 and 2022, when more male students passed. Because it fluctuates more gradually and necessitates greater work and intervention inputs than enrollment, gender parity, and completion rates, the pass rate is a more structural indicator than those alone (Agbenyo & Sarkpoh, 2021). Agbenyo & Sarkpoh (2021) found that in the Ghanaian district of Kadjebi, men outperformed women in the BECE and WASSCE exams. Numerous elements have been identified by researchers (Kyei et al., 2011; Kankpi & Graham, 2022) as influencing females' performance in senior high school The BECE aggregate, BECE grade in math, BECE grade in science, length of SHS education, kind of basic school, and age at last birthday at time of entering SHS were found to be

predictive of students' performance in a discriminant analysis conducted by Akaboha & Kwofie (2016) to identify the factors that have a significant influence in predicting students' performance in the WASSCE. The only element that most significantly influences the prediction of students' performance on the WSSCE is their Science BECE grade. This is followed by BECE grade in Mathematics, Type of basic school education and Duration of SHS programme, with BECE Aggregate and Age admitted to SHS 1, followed closely with virtually equal effect. The performance in the WASSCE decreases with decreasing BECE grade in Science.

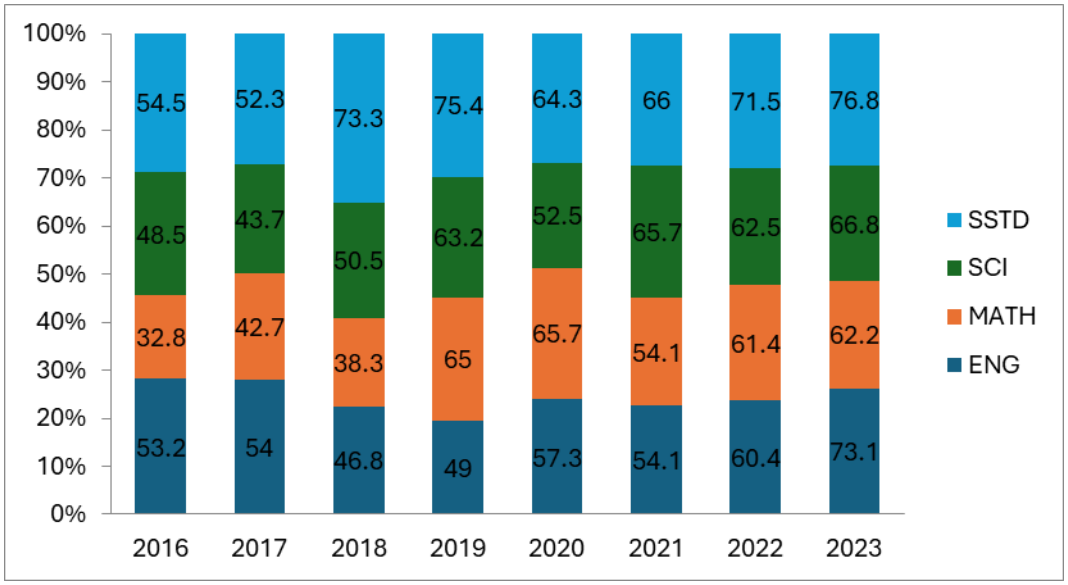


Figure 2. Pass Rate of Core Subjects

Source: Based on data from WAEC

Enrolment in the tertiary institutions has continued to experience marked increases over the past five years with current enrolment at 437,576 as shown in Figure 3. This represents an increase of 3.7% over the previous academic year. Private enrolment represents about 16% of total enrolment and in terms of institutions constitutes 54% (MoE, 2018). In 2019, there were about 496,148 students enrolled in Ghana higher education, respectively (Sasu, 2020). However, there are more males (263,772) than females (208,572) in tertiary institutions (Ghana National Accreditation Board (GNAB), 2020). There are about 230 institutions of higher education in Ghana (Acquah, 2021). Huge numbers of students do apply every year to higher education in Ghana. In Ghana like other countries, a candidate seeking a higher education can apply to more than one institution. This results in higher number of applicants and does not reflect in the actual number of students seeking admission. The options of buying more forms to seek admission into higher education is due to the competitive nature of seeking higher education in Ghana and the choice of program of the applicant. From Figure 2, a total of 437,576students were recorded to be enrolled in various programmes for the 2017/2018 academic year. This shows an increase of 5.18% from the Figure of 422,122 students recorded in the previous academic year (Figure 2). Public Universities enrolled the highest number in 2017/18 of 244,079. The information above revealed that public universities (which are 9 in number) have been enrolling higher number of qualified candidates. Most of the tertiary institutions enrollment number keeps increasing with the exception of polytechnics and specialized/Professional Institutions.

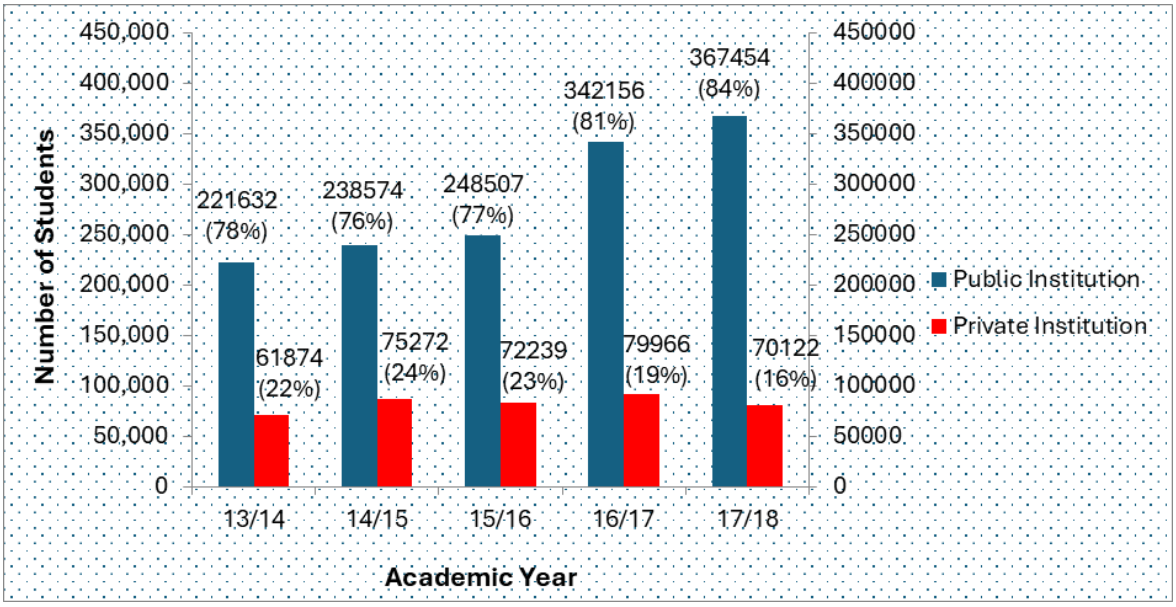


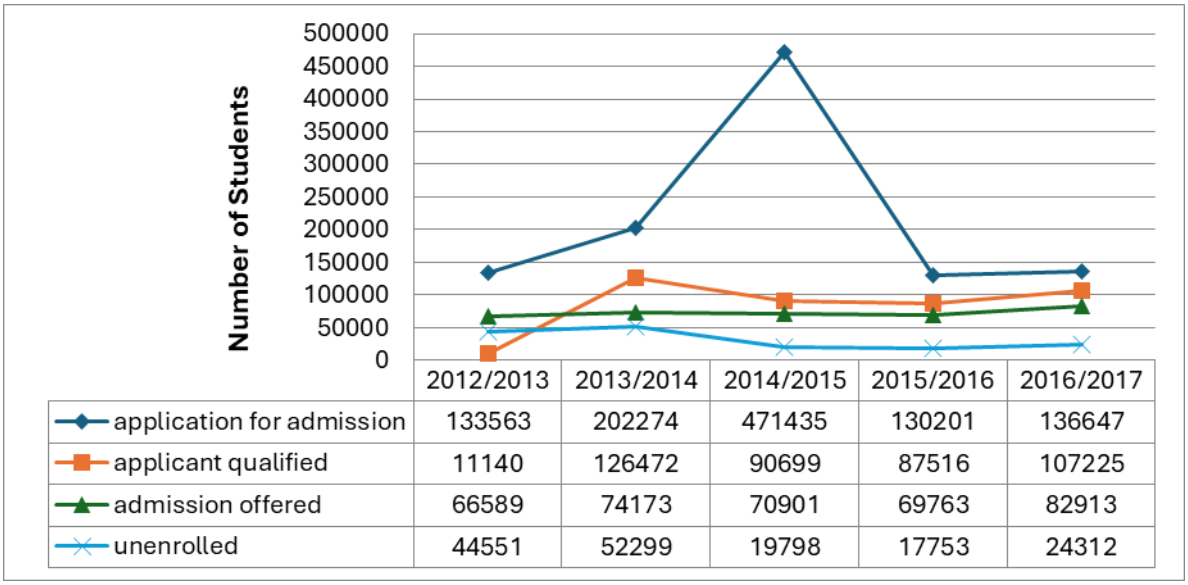
Figure 3. Enrolment Across Tertiary Institutions

Source: Data from MoE 2018

Undoubtedly, tertiary institutions receive huge applicants to be selected based on academic and available residential facilities. A comparative analysis of the dataset by NCTE (2018) for the last three academic years (2014/2015–2016/2017) using 2014/2015 in Ghana as the base year shows a reduction by 72.38% and 71.01% in student applications for 2015/2016 and 2016/2017 respectively (Figure 4). the dataset of the new entrants to the universities for the same period portrays a reduction in enrolment by 0.94% and an increase in enrolment by 3.387% for 2015/16 and 2016/17 respectively (Figure 4). From the Figure it is difficult to tell whether the huge number of qualified student applicants do not get admission into the universities. Even though the Figure shown do not reflect the true number of applicants due to some students buying multiple application forms, the figures involved are significant. The very few tertiary institutions with limited academic and residential facilities are to occupy the growing population of candidates seeking access to tertiary education and this has made universities in Ghana to be filled above its carrying capacity in terms of residential and academic facilities. There are very few academic and residential facilities to compete by large number of applicants, so, universities adopt highly selective admission procedures to select applicants (Atuahene & Owusu-Ansah, 2013). In most cases where there are options of choosing two programs of choice owing to the competitive nature of getting first choice of selected program.

When students in accessing tertiary education are denied owing to the limited infrastructure faced by tertiary institutions, it means that greater number of human resources is been underutilize. This can lead to limited number of professionals in the fields of law, medicine, engineering, security services, pharmacy and other professions. This situation is not in Ghana alone since it is a worldwide problem in terms of access to tertiary education. However in recent times, many students are been admitted but faced accommodation challenges due to the limited hostel facilities. The biggest challenge for the higher education selection in Ghana was revealed in 2020/2021 academic year where huge numbers from pre-tertiary students applied. This is, perhaps, due to the free SHS policy in place, and it suggests that if many students from this policy qualify for tertiary, it will

overstretch tertiary education capacities. In other words, institutions will be forced to accept more students than the required carrying capacity. A recent scenario is seen in the University of Ghana, where there is track run for students. Not only this, access to residential facilities has also become a problem. In some instances where the lecture halls cannot accommodate the required number of students, quality education becomes compromised. Again resorting to online in Ghana comes with its own challenges such as high data cost, network challenges and unwillingness on the part of some students and lecturers to use online medium. This does not only degrade the quality of higher education but it cost employers to retrain these graduates when employed.



	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017
application for admission	133563	202274	471435	130201	136647
applicant qualified	11140	126472	90699	87516	107225
admission offered	66589	74173	70901	69763	82913
unenrolled	44551	52299	19798	17753	24312

Figure 4. Admissions into Full-Time (Regular) Study from 2012/2013 to 2016/2017

Source: Based on data from National Council for Tertiary Education 2018

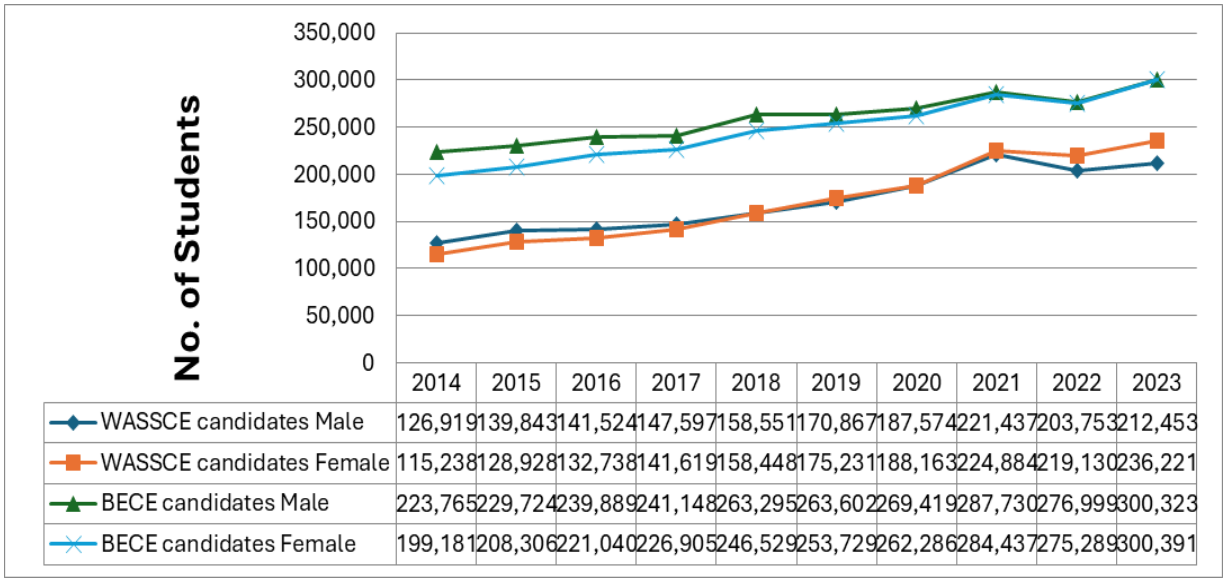
Causes of STEM Disparities

Completion Rate for Basic and Second Cycle Institutions

Intake at the primary level is higher for females (103.1) than males (95.4%) (GSS, 2018). Despite the large intake, the national completion rate is 71%, with girls having the greatest percentage of primary school completion (Associates for Change (AfC), 2022). BECE and WASSCE are the two main external exams written by Ghanaian youth in order to gain access to secondary and tertiary education. While BECE serve as passage to SHS, WASSCE provides access to tertiary education. The number of students writing BECE and WASSE has increased over the years (Figure 5).

Currently, gender disparities have been eliminated in BECE and WASSCE side as there are even more females than males currently completing JHS and SHS. There was higher number of males than females for WASSCE from 2014 to 2017, however the situation changed in 2018 onwards. With the emergence of free SHS policy in 2017, enrollment has increase in both ends with higher number of individuals writing WASSCE (Figure 5). From 2019, there are more females than males in writing WASSCE exams (Figure 5). However, this situation does not guarantee that there will be more females in tertiary institutions in the years to come if free SHS

continues since university admission is dependent on minimum admission requirement for a program. . The data on BECE and WASSCE candidates is very encouraging as there has been a reduction of dropout and completion rate increased.(AfC), 2022) reported that in comparison to children in urban communities, rural children have a lower completion rate at the primary level, despite their high enrolment. However GSS(2018) stated that completion rates were low in the three northern areas of Northern, Upper East, and Upper West compared to the other regions. .

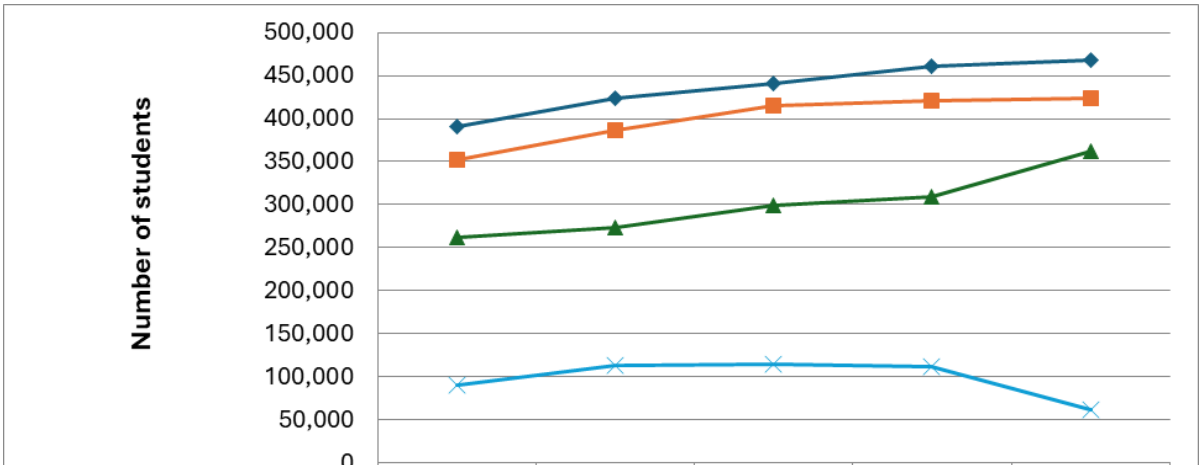


	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
WASSCE candidates Male	126,919	139,843	141,524	147,597	158,551	170,867	187,574	221,437	203,753	212,453
WASSCE candidates Female	115,238	128,928	132,738	141,619	158,448	175,231	188,163	224,884	219,130	236,221
BECE candidates Male	223,765	229,724	239,889	241,148	263,295	263,602	269,419	287,730	276,999	300,323
BECE candidates Female	199,181	208,306	221,040	226,905	246,529	253,729	262,286	284,437	275,289	300,391

Figure 5. Trends of BECE and WASSCE Candidates in Ghana

Source: Based on data from WAEC (2014-2023)

The quality of JHS education is dependent on BECE performance and also on the number placed into SHS and not the number of students enrolled because several factors affect enrollment of students into SHS. JHS is therefore the production center for SHS in Ghana and serve as the progression medium of JHS 3 students to SHS 1. The number of students writing BECE, the number of students placed, and number of students enrolled into respective SHS has increased over the years (Figure 6). This has also drastically reduced the number of students placed and not enrolled. From Figure 6, for the period 2013 to 2016 more than 90,000 students placed each year were unable to enroll. The underlying reasons were financial (MoE, 2018). Poverty keeps children out of school. Boateng & Ansah, (2014) stated that financial constraint affects students' enrolment and further argued that school-going children from poor households are three times expected to be out of school than those from affluent homes. They were of the view that location of residence was an important determiner on enrollment of students and said that rural children were nearly twice as likely to be out of school as urban children. However, with the implementation of free SHS in 2017/2018 academic year, enrolment has increased with reduction in the number of students placed and not enrolled. Despite increase in enrolment, there exist a high number of students who are not enrolled. Data from MoE shows that completion rate for 2009-2017 at the SHS level is higher for males than females (Figure 7). High completion rate means more students are expected to enroll into various tertiary institutions.



	2013	2014	2015	2016	2017
Total Registered (BECE)	391,032	422,946	440,469	461,009	468,060
Number placed	352,202	386,412	415,012	420,135	424,224
Number enrolled	261,598	273,152	299,649	308,799	362,075
Number placed but not enrolled	90,604	113,260	115,363	111,336	62,149

Figure 6. Trends in Admission vs. Placement

Source: Based on data from Ministry of Education (2018)

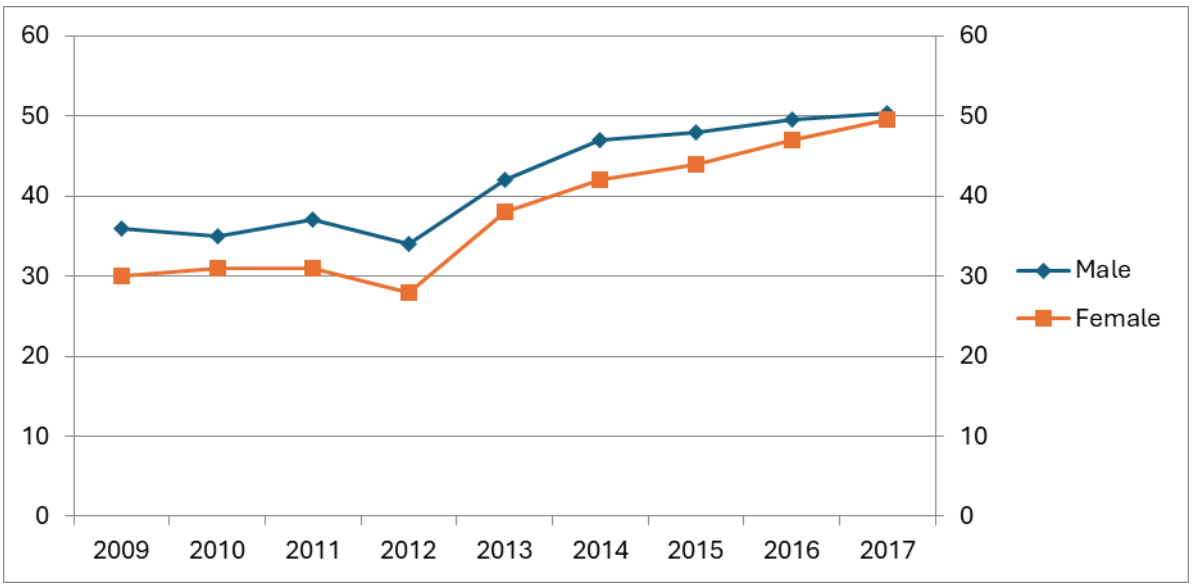


Figure 7. Gender Parity Statistics on SHS Completion Rate

Source: MoE 2018

Gender Disparity in Tertiary Education

Completion rate of male and female at the SHS has almost been equal as at 2017 (Figure 7), however, with regards to higher education, there exist disparities in the access for female students in most part of the world. In Africa, the issue with respect to disparity, is often attributed to colonial education where women were neglected in education especially in higher education. Ghana has recorded an increase in higher education with GER

increasing from 2.92 to 12.14 between 1999 and 2011(Atuahene and Owusu-Ansah, 2013). Despite this impressive achievement, inequality and inequity still exist between male and female. Data from the UNESCO institute of statistics (2021) estimated that there are 265,188 primary aged children who are out of school in Ghana. Out of the said Figure there were 155,175 males and 110,013 females out of school. In addition, there are 2,126,094 adolescent and youth out of school as at 2020 (Table 2).This deficit affects the level of enrolment into tertiary institution. Data showed that Gender Parity Index (GPI) rose to 0.62 in 2011 from 0.45 in 2008 (Atuahene and Owusu-Ansah, 2013). The Gender Parity Index for Tertiary Education in Ghana stands at 0.69, indicating that big gender inequality exists at the higher level education (Marchetta & Dilly, 2019).

Table 2. Out of School Children and Adolescent 2015-2020

Out of School adolescents and youth	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Out of School adolescents and youth of secondary school age, both sexes (12-17)	858,516	902,520	910,194	887,784	724,820	620,302
Out of School adolescents of lower secondary school age, both sexes (12-14)	174,586	219,240	228,204	299,372	208,105	152,569
Out of School youth of upper secondary school age, both sexes (15-17)	683,930	683,280	681,990	588,412	516,715	467,733
Out of School children, adolescent and youth of primary and lower secondary school age both sexes	858,516	902,520	1,000,898	1,041,770	760,252	885,490

Source: UIS Statistics, 2021

Data from UNESCO show that the gender distributions of male and female in tertiary institutions revealed gaps. Although distribution of male and female in higher education is on the increase, females are still behind from 5.15: 12.16 female to male ratio in 2008 to 13.37: 18.65 female to male ratio in 2016 as indicated in Table 3. In Ghana, the gender gap was at 3.3 years by 1985 before starting to decline (Evans *et al.*, 2019). Progress has been a lot of more slow in Ghana and Iraq: if current trends continue there, gender gaps in fulfillment won't vanish until 2042 and 2098 separately (Evans *et al.*, 2019).

Table 3. Gender Distribution of Students in Higher Education in Ghana from 2008-2016

Gender	**Year**								
	2008	2009	2010	2011	2012	2013	2014	2015	2016
Female	5.15	6.67	-	8.99	9.27	11.1	12.7	13.23	13.37
Male	12.16	11.38	-	15.2	15.17	17.61	19.14	19.13	18.65

Source: UNESCO (2008-2016)

Enrollment of female students into tertiary institutions keep increasing where as that of men has not been consistent. From Figure 8, 2015 enrollment of females was almost thrice of the number recorded in 2014. This therefore indicates that since 2015, growth of female enrollment has been steadily unlike the huge margin that occurred in 2014. There has been inconsistent growth of male students in tertiary institutions. Female percentages against that of the males over the years have been below 50%. There is decline of the percentages of male enrollment into tertiary institutions. Aside 2014-2015 of females' percentage growth of 21%, the next high percentage growth of 3% for females was 2018-2019. Despite this growth of female enrollment in tertiary institutions, there are still gender disparities in STEM education. Data from UNESCO (2020) revealed that the average ratio of female to male for students in tertiary level education in 2018 based on 113 countries in the world was 1.14 percent. The highest value was in Qatar 1.87 percent and the lowest value was in Afghanistan: 0.35 percent (UNESCO, 2020). The average for 2018 based on 16 countries in Sub Sahara Africa was 0.85 percent. The highest value was in the Seychelles: 1.52 percent and the lowest value was in Niger: 0.41 percent. The average value for Ghana during that period was 0.47 percent with a minimum of 0.17 percent in 1971 and a maximum of 0.85 percent in 2019(theglobaleconomy.com).

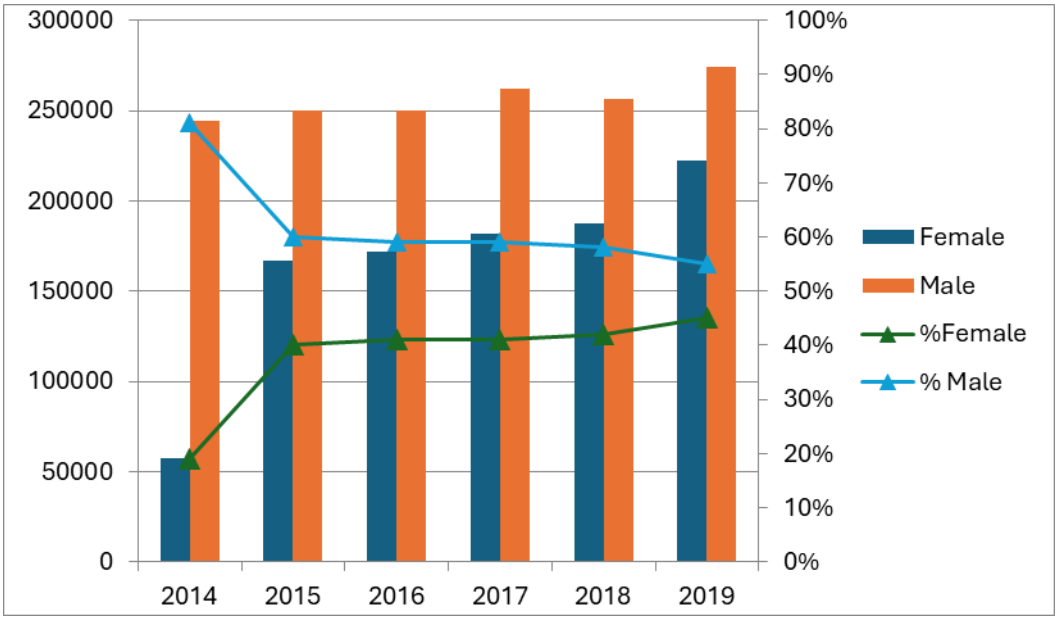


Figure 8. Tertiary Data on Enrolment in Ghana from 2014-2019

Source: UNESCO (2014-2019)

According to MoE (2018) females constitute 50% and more only in Colleges of Education, and Nursing training colleges. Females are underrepresented in most of the categories of tertiary institutions especially at the Colleges of Agriculture with only 15.90% female participation (Table 4). There were significance differences ($p<0.05$) in the gender and the type of tertiary institution. Student enrolment in the Private Universities has always been increasing due to the increasing number of accredited private tertiary institutions that exist. With the exception of Public Nurses Training& Allied Health Training Colleges and Private Nurses Training Colleges, females are underrepresented in the rest of the tertiary institutions. Whiles enrollments in public tertiary institutions have been increasing, that of private tertiary institutions has been fluctuating. In Ghana, private tertiary institutions charge high fees as against public institutions. The uncontrollable nature of fees disparities

between private and public institutions will affect accommodation and quality of teaching in public institution since many students seeking tertiary education will apply and get enrolled into public institutions.

Table 4. Gender based Enrolment in Tertiary Institutions by Type of Institution

Institution	**2015/2016**		**2016/2017**		**2017/2018**		**2018/2019**		**2019/2020**		**2020/2021**	
	M	F	M	F	M	F	M	F	M	F	M	F
Public Universities	135139	84457	156413	102256	147170	96909	164189	119872	178200	138827	187611	145175
Polytechnics/Technical Universities	34688	18077	33365	17567	3207	19826	31095	19744	34303	22307	39898	23830
Public Colleges of Education	23611	19142	24041	20772	25664	22489	25434	22651	24888	22697	26107	27213
Private Colleges of Education	4241	3578	2721	2475	3043	3095	2970	4124	3242	4545	2318	3523
Public Specialized Institutions	7213	6065	5692	4631	6265	4993	5831	5957	6026	6500	5945	6292
Private Universities	41234	30093	37350	28672	36455	26997	37208	27580	35786	27459	32332	29324
Public Nurses Training& Allied Health Training Colleges	3574	10027	1634	4691	4263	12675	6729	21581	10114	30366	10949	38098
Private Nurses Training Colleges	159	661	270	668	147	385	140	397	427	630	397	700
Colleges of Agriculture	143	20	652	108	513	97	536	113	570	158	746	293
P-value	<0.05		<0.05		<0.05		<0.05		<0.05		<0.05	

Source: UNESCO, 2022

Program Disparity in Tertiary Institutions

The science programs include agriculture, applied science, engineering, and science. The arts program includes arts and Social Science and business. The research did not factor in educational programs since such programs is a mixture of pure/applied science and arts and social science. The number of candidates for science related programs at the tertiary level of education is mostly dependent on number of science students in SHS and other factors. In most SHS, there are more arts classes than science class. In SHS, the science classes comprise of general science and the home science classes. The general science classes mostly have the combination of four electives: biology, chemistry, physics, elective mathematics and geography. Not all SHSs have both general science and home science classes. Even where it exists, the number of students offering these programs is below the art classes. The underlying cause for this is the choice made by students when they are at the JHS level. Whereas many students see that is it easy to enter good schools, one opt for arts programs than science, others see science to be very difficult. Like a food chain, this has effect on the number of students studying science and arts at the tertiary level. According to Ministry of Education, Science and Sports (MOESS, 2010) lack of tutors in science and technology related fields, lack of support for females to pursue STEM programs and unfurnished laboratories in SHS account for such disparities between science and arts programs. Lorenz Curve offers more estimation of Ghana's shortcomings in reaching gender equity or parity in its tertiary education system as shown

in Figure 9 as the curve is a tool used to quantify equality.

d'Hombres (2010) stated that Lorenz Curve plots the cumulative educational share against the cumulative population share, with the least and most represented groups on the y- and x-axes, respectively, representing tertiary education. A graphic picture of educational disparities is offered the Lorenz curve ((Atuahene and Owusu-Ansah, 2013). The Lorenz curve is distinguished by the 45° diagonal line. The relationship between cumulative proportions is represented by the Lorenz Curve in Figure 9, with coordinates for its initial and final points being (0, 0) and (1, 1), respectively. The Lorenz Curve would match the equality line if the enrollment distribution for each gender group was the same. The equidistribution line is not reached by the Lorenz Curve because of the unequal enrollment distribution of male and female students. The degree of disparity in the enrollment distribution and participation is determined by the surface of the area between the 45° line and the point on the Lorenz curve where the enrollment distribution of the two social groups (male and female) is equal. The degree of inequality in the distribution of educational attainment increases with surface area; conversely, the greater the deviation of the curve from the diagonal line, the greater the inequality indicating that gender disparity exist at the tertiary level of education. From Figure 9, it is evidenced that educational inequalities exist between male and female students with access favoring male students who are closer to the equidistribution line.

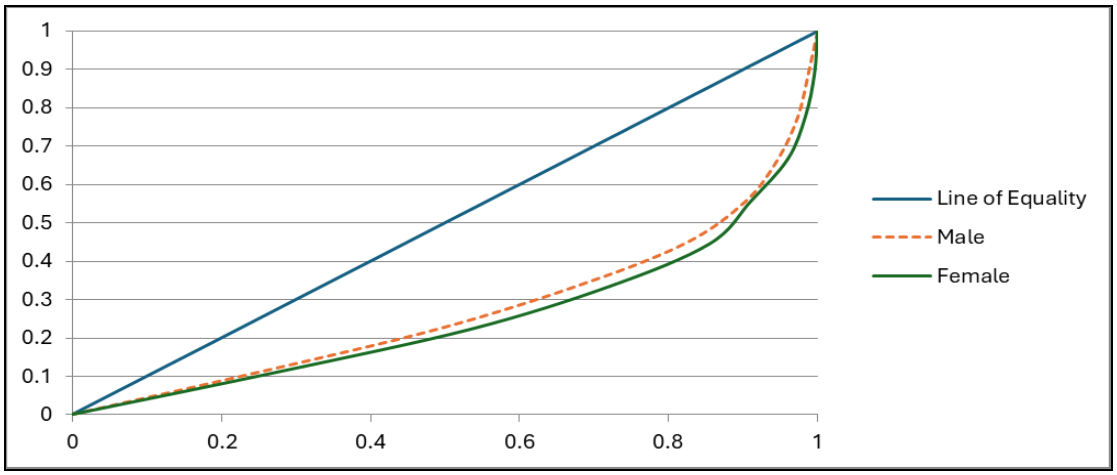
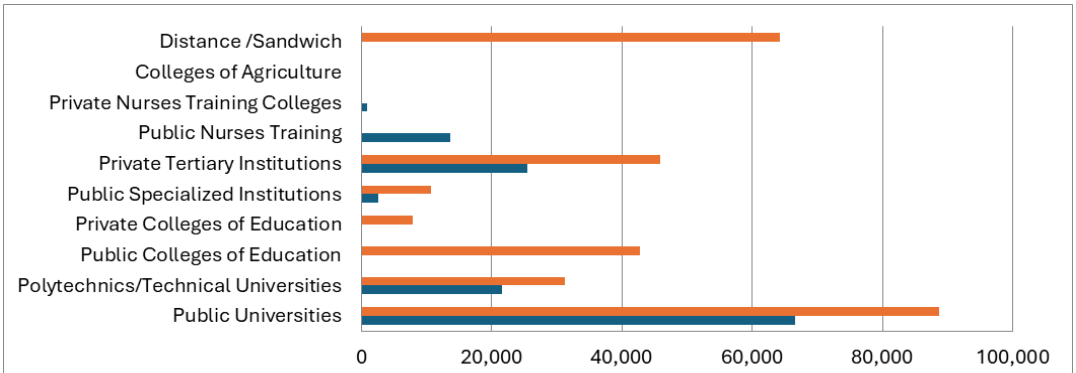


Figure 9. Educational Lorenz Curve between Male and Female Students: 2019.

Source. Author's calculations based on GNAB data (2020).

Data from NCTE (2018) revealed that in the 2016/2017 academic year, 43% of the full-time students were enrolled in Social Science and Humanities programmes, 19% of the students were enrolled in Science related programmes, 16% of the students are enrolled in Business Administration programmes, 11% of the students were enrolled in Applied Science, Technology and Health Science related programmes, 6%ofthestudentsin Engineering programmes,4%ofthe students were enrolled in Medicine programmes and the remaining 1% in Pharmacy programmes. It is evident that the universities are training more people in Arts related fields, hence there will be more people with arts or humanities background than science and engineering backgrounds for the labour market. The situation is the same in private tertiary institutions where student's enrolment over the years has been higher in Arts related programmes because majority of the institutions predominantly run Arts related programmes. Out of the 66,022 students enrolled in the private tertiary institutions for the 2016/17 academic

year, 43,649 students are pursuing Arts related programs whiles the remaining 22,373 students were studying Science related programmes. The target of 60:40 enrollments in science:arts has not been able to achieve due to the aforementioned circumstances. In 2017/2018, as indicated by the Figure 10, public universities admitted 88,766 arts students as against 66,636 science students. The enrollment in science: Arts in 2017/18 was 31:69%. Again the disparities situation is high at the polytechnics, private tertiary institutions, public specialized institutions and distance/sandwich.



	Public Universities	Polytechnics/Technical Universities	Public Colleges of Education	Private Colleges of Education	Public Specialized Institutions	Private Tertiary Institutions	Public Nurses Training	Private Nurses Training Colleges	Colleges of Agriculture	Distance /Sandwich
Arts	88,766	31,209	42,753	7,819	10,750	45,833	0	0	0	64,194
Science	66,636	21,556			2,528	25,494	13,601	820	163	

Figure 10. Enrolment in Science and Non-science Disciplines for 2017/18

Source: MoE 2018

Globally, disparities in STEM disciplines exist since male enrolments outweigh female enrolments. In Ghana and many other African countries, enrollment into STEM disciplines is a challenge at the higher level especially for women. This is due to the earlier stated reasons: condition where few women or girls study science at the SHS level and the subsequent small number of women who qualified to be enrolled in STEM programs. Past data in series from MoE (2010) for five universities revealed disparities in enrollment between males and females in both arts and STEM as shown in Figure 11. The data set shows that University of Ghana (UG) enrolled most students when arts and science students are combined than the rest of the universities. However University of Science and Technology (UST) enroll the highest number of students in STEM programs indicating that UST if the hotspot for STEM programs in Ghana. In all the five universities male enrolment outnumbered that of females in STEM programs. In 2011 close to 40% women were enrolled in science and technology programs in Canada (CNHS, 2011). The age range of the women was 25 to 34. This was lower when compared to those offering non science and technology programs. In USA, 24% of women enrolled in science and technology programs as at 2009 (Beede *et al.,* 2011). Disparities is mostly found in STEM programs than non-STEM programs; however, challenges faced by women in the pursue of higher education in STEM in Africa is numerous and clear (Mabokela & Mlambo 2015). The resulting effect is seen in the number of women in STEM work areas. In Africa countries such as Angola (40%), South Africa (39%) and Namibia (39%) had the largest female representative in science and technology facilities with Mozambique (23%),

Zimbabwe (24%) and Lesotho (26%) having the lowest (Morna & Jambaya-Nyakujara, 2011).

In Ghana, out of 69,214 enrolled in Science related programmes (Engineering, Medicine, Applied Science, etc.), 70% were males and 30% were females. It is evident that the universities in Ghana are training more people in Arts related fields (NCTE, 2018). Tertiary institutions that use to be science related has gradually introduced arts and humanities. Out of the 66,022 students enrolled in the private tertiary institutions for the 2016/17 academic year 22,373 students were studying Science related programmes. With respect to the science related programmes, there were 14,890 male students and 7,483 female students enrolled and studying science related programmes (NCTE, 2018). This limited number of females pursuing STEM in Ghana presents a challenge for the other females to see them as role models and emulate them. There has been a projection by MoE from 2017 to 2030. Among is the increase of tertiary GER, science to humanities ratio. Quarshie *et al.*, (2023) reported in their study that gender disparity continues to exist at the KNUST, despite considerable gains made over the last decade. They further stated that while female participation out strips males in the Health Sciences, they generally trail their male counterparts in all other fields, particularly Engineering and the Sciences. University of Education has the highest enrollment of 67381, out of which 39378(58%) are males and 28003(42%) are females, followed by University of Cape Coast (GNAB, 2020). The underlying reason for high numbers in these two universities is that offer educational programs to produce competent teachers. In Ghana, mass employment mostly seen in the education and health sector other than industries and as such people will prefer where there is ready market for jobs.

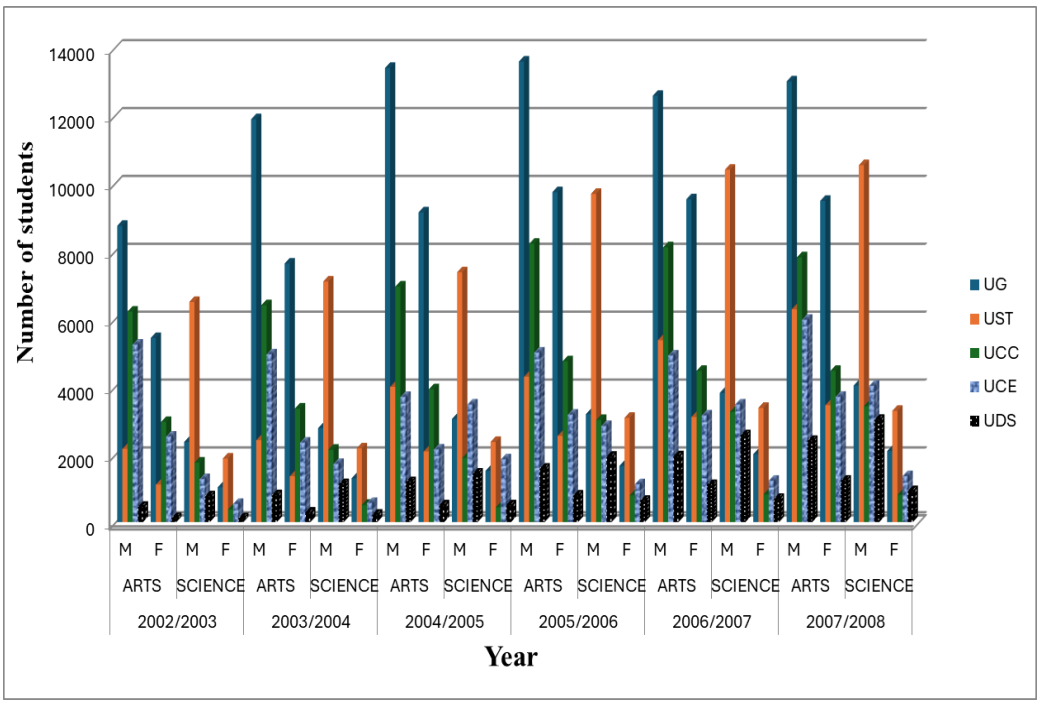


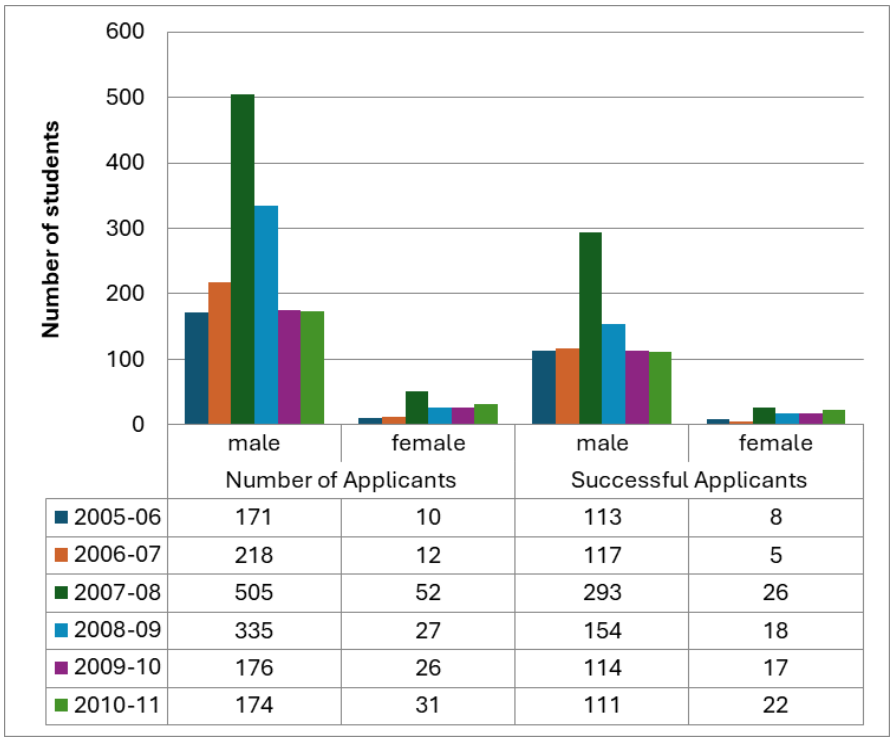
Figure 11. Enrollment DISPARITIES in Science and Arts Disciplines (UG-University of Ghana, UST-University of Science and technology, UCC-University of Cape Coast, UCE-University College of Education, UDS-University of Development Studies)

M-Male F-Female

Source: MoE2010

Gender-based Disparity in Financial Aid

Hunger, stigma, internal isolation, and other issues that negatively impact their learning experiences are common struggles faced by students from low-income rural homes and urban informal settlements (UNICEF, 2019). Due to the requirement for additional labor to augment family income, impoverished parents in many Ghanaian rural communities cannot afford to enroll all of their children in school (AfC, 2022). Family decisions regarding how many children to enroll in school must therefore be made (Casely-Hayford et al., 2017). The information that was available showed differences in the cost structures of scientific and art programs. Tuition for STEM programs is more than that of arts and humanities programs. Many students who finished STEM-related undergraduate programs are unable to pursue master's and doctoral degrees due to the aforementioned reasons. The cost of tuition for various degrees varies both within and between universities (Atuahene & Owusu-Ansah, 2013). Financial aid is important in pursuing higher education. In Ghana, there are several financial aids that support students in tertiary institutions. These come in the form of loans and scholarships such as the GNPC scholarship, COCOBOD scholarship, student loan, Kuffour Scholarship, Vodafone scholarship, Vice Chancellors scholarship, mastercard and others. While some scholarships are for students in a particular institution others are open for everyone irrespective of tertiary institution. Assessment of financial aids revealed gender disparities. Data from University of Ghana on financial aid application and the success of applicants revealed wide gaps. In each of the year, there were more male applicants than females. The data revealed that low number of females do apply for financial aid. The large the number of applicants, the more slot is given. In 2005-06 academic year a total of 181 students applied of which 171 were males and 10 females as shown in Figure 12.



	Number of Applicants		Successful Applicants	
	male	female	male	female
2005-06	171	10	113	8
2006-07	218	12	117	5
2007-08	505	52	293	26
2008-09	335	27	154	18
2009-10	176	26	114	17
2010-11	174	31	111	22

Figure 12. Financial Aid for Students

Source: University of Ghana (https://www.ug.edu.gh/aid/statistics)

Of these numbers, the number of successful applicants for males was 113 against 8 females. The number of applicants and the successful applicants did not differ in the subsequent years however the data did not provide the number of applicants based on students program of study (science vs arts) and the type of scholarships. Quarshie *et al.,* (2023) attributed this to low awareness creation on the scholarship opportunities in tertiary institution.

Gender-based Disparity in Mode of Enrolment by Type of Institution

Atuahene and Owusu-Ansah (2013) stated that participation in higher education depends on the location and quality of Senior High School attended, which is also a proxy to measure ones performance in the Senior Secondary School Examinations (SSSCE). They further stated that performance in SSSCE/WASSCE depends on the geographical location or region of the high school, academic program, and of course the quality of teachers in the school. Students who have the opportunity to attend one of the top-ranked Secondary Schools, staffed with quality teachers and comparatively better educational facilities tend to perform better than their peers who attended mediocre Senior High School, predominantly located in rural areas in historically disadvantaged regions of the country, which have substandard academic infrastructure or facilities. Such students are able to advance their education when there is no financial barrier. Data set revealed lower progression from first degree to masters and then to PhD (Table 8). Data from Ghana National Accreditation Board (2020) revealed that the number of male students pursuing masters (research and non-research) was one tenth of those pursuing bachelor's degree. This was similar for female students.

Table 8. Disparity in Mode of Enrolment by Type of Institution

Type of institution	**Diploma**		**Bachelor**		**Masters (non research)**		**Masters (research)**		**PhD**	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
PU	21990	21656	119437	78478	8721	5281	4170	2380	1478	595
S/PTEIs	703	709	3825	3503	585	469	-	-	2	9
P/TU	27045	17626	3772	1909	-		26	20	-	-
CoA	536	113	-	-	-	-	-	-	-	-
PCoE	24548	22277	-	-	-	-	-	-	-	-
PNMTC	6673	20604	-	-	-	-	-	-	-	-
PrU	2112	1250	32526	25918	1864	934	101	15	121	27
PrCoE	2888	4077	-	-	-	-	-	-	-	-
PrNMTC	135	397	-	-	-	-	-	-	-	-
Total	86630	88709	159560	109808	11170	6684	4297	2415	1601	631

PU(Public Universities), S/P TEIs (Speacilized/Professional Tertiary Education Intitutions, P/TU(Polytechnics/Technical Universities), CoA (Colleges of Agriculture), PCoE (Public Colleges of Education), PNMTC (Public Nursing Midwifery Training College), PrU)Private Universities) PrCoE (Private Colleges of Education), PrNMTC (Private Nursing Midwifery Training College)

Source: Ghana National Accreditation Board (2020)

The underlying reasons for the above data is unknown, however, in a study conducted by Andoh (2017) on uptake of doctoral thesis research (in STEM program) in Ghana, Andoh (2017) found out that most people believe studying for a PhD abroad (outside home country) has an effect on the type and quality of one's research during and after obtaining a PhD. In addition, many believed undertaking a PhD abroad gives one opportunities to present findings during and in some cases after studies. He further stated that people who obtained their PhDs in Ghana tried several times getting admission and full scholarships to study outside Ghana. In his study, some of the interviewees complained about stress in their undergraduate thesis in the program of study made them lose interest in pursuing further studies while others were brainwashed by their colleague who have done their further studies in Ghana. Others also believe that access to equipment is much easier in abroad than Ghana. Due to the lack of facilities and financial support, quality of postgraduate researches in Ghana is very low.

The impact of facilities such as laboratory or field equipment for STEM education and further education (masters and PhD) cannot be overemphasized. There is insufficient practical activity in most STEM programs especially during first degree in Ghana. This makes furthering of education in STEM becomes worrisome for many which eventually causes low enrolment in Masters and PhD programs. The ICT infrastructure in terms of access and usage in many tertiary institutions is weak. In addition teachers/lecturers also have limited knowledge and skill in using technology, often at the most basic level, making it a challenge for teachers to integrate technology in teaching and learning effectively (Taddese, 2020) thereby making STEM education unattractive for students to pursue at higher level. Aside difficulties in having access to facilities on universities campus, ownership of facilities such as mobile phones, laptops and access to uninterrupted internet access and electricity in household for personal learning is difficult. At the national level, household ownership of mobile phones is high (92%) but low for computers (15%). Smartphone ownership increased significantly between 2013 and 2017, with approximately one-third of adults owning a smartphone in 2017 (Silver and Johnson, 2018). Households also have limited access to the internet (22%).Disparities in access to EdTech infrastructure across urban and rural regions are highest for the internet and computer however it is lowest for radio. While access to electricity is highest for senior high schools (78.6%), it is low for junior high schools (49%) and worst at the primary level (29%) (UNESCO, 2018). None of the levels of education had percentage of internet access very close to 50%. This was the same for computers for teaching and learning. In 2020, data from the university Ghana revealed that there were more males (3869) of 52.6% than females (3484) of 47.4% in graduate studies. Andoh (2017) attributed this program disparities that to undertake PhD studies in developing countries like Ghana, have its own challenges. The unsuitable timeliness, the lack of facilities, and funding opportunities are some of the challenges that discourage students from undertaking their studies in Ghana.

Government Policies and Universities Strategic Plans

One neglected issue of gender disparities in education is teenage pregnancies and this affect STEM education too. Several studies (UNICEF 2012; Casely-Hayford 2018) have documented the detrimental effects of adolescent pregnancies and early marriages on females' ability to complete their education. According to a recent Ghanaian research on adolescent pregnancies, 2,865 girls between the ages of 10 and 14 were pregnant in 2020, while 107,023 females between the ages of 15 and 19 did the same. There has been a rise in the number of

adolescent pregnancies in Ghana in 2019. The likelihood that the majority of these girls will not continue their education after giving child is considerable, even though there is no reliable statistics on the number of girls who return to school after giving birth. Disparities will persist since many of these girls are not going back to school. Several policies have been instituted to bridge the gap of gender disparities in tertiary education, however where policies and strategies do exist, implementation barriers include inadequate infrastructure and resources, poor planning, under-trained teachers, and inadequate materials (Rose *et al.*, 2019). These include the National Science, Technology and Innovation Policy (NSTIP) (2010), Science, Mathematics, and Technology Education (STME) and others. However, NSTIP implementation faced significant challenges, particularly regarding meeting the significant funding requirements, equipment maintenance, and cost of Internet access (UNCTAD, 2011) and as such the MoE developed information, communication and technology (ICT) policy to achieve the aim of bridging the gap. STME clinics were developed and this lead to total of 40,908 girls attended clinics and camps from 1986 to 2010 (MEST, 2010). The above program and other initiatives managed to increase girls' participation from 12% to 25% within 25 years; thus, this intervention led to increased enrolment of female students in S&T programs in the universities and polytechnics in Ghana (MEST, 2010).

The national gender policy was enacted to operationalize government's commitments to achieving gender equality and women's empowerment targets, in its national vision of, "A stable, united, inclusive and prosperous country with opportunities for all" **(**Ministry of Gender, Children and Social Protection (MoGCSP), 2015). MoGCSP (2015) admitted that in terms to access to science and education, gender gap exists in access to science and technology, digital knowledge and skills. The challenge is how to bridge the gap to include women's needs and strategic interests in the establishment of digital knowledge–based society. Aside the gender policy is the Education Strategic Plan (ESP). The Education Strategic Plan (ESP) 2018–2030 is the third in a series of strategic plans that have been produced since 2000 (ESP 2003–15; ESP 2010–20; and now 2018–30) and follows from the ESP 2010–2020.The ESP 2018–2030 provides a 12-year roadmap for education in Ghana. This ESP 2018–2030 has targets meant to be achieved (Ministry of Education (MoE), 2018) and these include a projection of tertiary GER. The Science: Humanities ratio projections gap is expected to be equal in 2020/2021 and expected to rise 55:45 for 2025/2026 and 60:40 for 2029/2030. Universities have their strategic development plan that governs the activities of the universities. This entails several plans related to gender issues, affirmative actions and projections made. In bridging the gender gap, affirmative actions have been implemented by universities in Ghana especially science and technology programs. There is implementation of quota system for admitting female students. Whilst some lower the cut-off point others have a number of female and male candidates to be offered admission based on a working percentage. Despite national and university policies in bridging the gap, it appears that efforts have been slow in achieving the gender gap. Though several policies exist, their implementation and monitoring of progress differ from what has been written.

Quarshie et al., (2023) discovered that the university's admission selection process (grade cut-off points) was another major factor contributing to gender disparity and low female participation in higher education. Another factor their study reported which was reported to militate against equal access to higher education was the mixed-oriented higher education structure. Additionally, low awareness of policy and opportunities were identified as contributors to gender disparity in the KNUST, especially in STEM fields. We found that although

the university had the STEM and WiSTEM policies in place, together with scholarship opportunities to help boost female enrollment in the institution, awareness about their existence was limited, particularly among the policy targets. There is little or no sensitization and awareness at the pre-tertiary and the tertiary level as well. Quarshie et al., (2023) stated that after the implementation of STEM, the trend line depicted an upward trend implying growth in female admission into STEM fields for the initial growth year (2017/2018–2018/2019). In the second growth year (2018/2019–2019/2020), the trend indicated a general decline in female admission by 194 applicants on average. They stated that the impact of the STEM policy on female admission was only evident in the Health Sciences and Engineering but failed to improve admissions in the Sciences. Again, the STEM policy tended to improve female enrollment in Health Science and Engineering but not in the Sciences.

Conclusions

Education in Ghana has improved in terms of access and enrollment however the quality of it still remains questionable. Ghana has done well to achieve gender parity at the kindergarten, primary, JHS and SHS thanks to policies such as FCUBE, free SHS and others, however these developments have not been seen in the tertiary level. Another positive part of Ghana Education is the increase in the progression rate of JHS 3 students to SHS 1 and this is revealed in the reduction of the number placed and not enrolled of BECE candidates. A worrying situation currently is the overstretched of universities carrying capacity as this will compromise quality tertiary education in Ghana. Despite this overstretched, females are still under represent in universities. Science related programs is still lower as compared to Arts programs with the root caused traced from choice made by JHS candidates when entering SHS and the small number of science classes as compared with arts classes in SHS. The increasing rate of polytechnics/technical universities offering arts related programs diverts the motive and vision in the set-up of polytechnics/technical universities. The offering and production of high number of arts graduates stipulates that STEM companies and institutions related will be bereaved of low number of STEM products in the future. Providing access to higher STEM education programs for qualified candidates in Ghana is a difficult task. Though access to higher education is financially higher however STEM related programs incur higher financial burden. Disparities do not exist only in access and enrollment, however in access to aid and facilities. Small numbers of students are given scholarship. Scholarships are men dominated in most cases due to higher number of male applicants. There is also lack of assistance for scholarship beneficiaries after their opportunities have elapsed. Either the scholarship awarding institutions have no plans after the expired period for the scholarship recipients or the tertiary institutions of the recipient have no interest in the success of their product after huge investment. This has led to loss of valuable human resources. Issues of lack of facilities and struggles (in terms of delays and data collection) to complete undergraduate STEM programs prevent many others for furthering their education. Despite several policies implemented by Government of Ghana (GoG) and universities, their implementation mostly do not match with the written documents as such little is been achievement. This creates disparities in Ghana educational system.

Owing to the current huge number of SHS graduates entering tertiary institutions which is as a result of the free SHS, Government of Ghana (GoG) must have the political will of expanding current tertiary institutions in terms of accommodation, lecture halls and laboratory facilities. Much support must therefore be given to

students in STEM especially female in STEM. STEM companies must provide scholarship support to students studying STEM programs from SHS to tertiary education. Companies that deal with specific areas such pharmaceutical, oil, mining, water, companies and many others must provide financial and other support to students in such fields. The number of science programs and classes must be increased. New combination of science programs must be introduced in SHS. Female students who have benefitted from any form of scholarship opportunities must be traced by scholarship awarding institutions and be engaged either with a new project or furthering of education. There is therefore the need for a centralized system in the Ghana Education Service and universities mainly for tracer study of scholarship beneficiaries. Number of scholarships awarded to female students must be increased. Mode of awarding scholarship and giving of student loans must be data based by the awarding institutions and not from self-reported data and favoritisms. There should be gender budgeting for STEM activities (seminars, workshops and celebration of science related international days) and its impact assessment must be measured. The gender budget should be spearheaded by the finance section in tertiary institutions, Ghana Education Service and Ministry of Education. The policy of upgrade of polytechnics into tertiary education status is positive however the higher number of arts students in technical universities do not only degrade the motive of establishing such universities but the impending lack of skill personnel in the years to come. Technical universities must therefore be a supplement to STEM programs in other universities. Teenage pregnancies need to be dealt with. Policies drafted and its implementation must be properly monitored and evaluated timely to the progress. Struggling tertiary institutions especially those with weak and poor lecture halls, limited accommodations, laboratories, internet access and other embattle issues such as sanitation, water, hygiene and many other issues will face a difficult task to bridge current STEM gender gap in their institutions. Therefore policies and plans zeroed in solely on young female's education may not be the best or effective approach to improve education results for young females and eventually that of females in STEM. Gender sensitive policies must be adopted and advocacy for STEM conferences to address barriers.

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