Factors which Contribute to or Inhibit Women in Science, Technology, Engineering, and Mathematics in Africa

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This report is the result of a survey response by several women in science, technology, engineering, and mathematics (STEM) and policy experts involved in data collection from across African institutions. We wish to express our appreciation for their participation. This report would not have been possible without their hard work and participation.

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Acronyms

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AAS	African Academy of Sciences
AWMA	African Women in Mathematics Association
GS	Gender Summit
IDI	In-Depth Interview
OWSD	Organization for Women in Science for the Developing World
SAGA	STEM and Gender Advancement
SDGs	Sustainable Development Goals
STEM	Science, Technology Engineering and Mathematics
UNESCO	United Nations Educational Scientific and Cultural Organization

Executive Summary

The United Nations has adopted an ambitious agenda for sustainable development expected to be accomplished by member countries by the year 2030. Innovation, science and technology is expected to play a significant role in the success of this development agenda. Unfortunately, countries across the globe are not fully utilizing the potential of the entire population, including girls and women in innovation, science and technology. Africa in particular continues to lag behind in the generation of the human technological capacity. Whereas efforts have been made to recruit and retain more women in science, technology engineering and mathematics (STEM), a stark gender disparity persists. It is clear that this inequity will not resolve itself solely by more generations of women moving through the academic pipeline. There is need for efforts to close the gender gap in STEM to ensure that women as much as men benefit as citizens and contributors to their societies.

Cognizant of the gender disparity in STEM, the African Academy of Sciences (AAS) conducted a study to assess factors contributing to or inhibiting women's careers in STEM in Africa. Specifically, the study aimed to identify the challenges and opportunities that women in STEM in Africa face through their career. A mixed methods approach was used to collect data that included conducting a scoping review of literature, in-depth interviews with a range of women working in STEM, and an online survey of women either working in STEM or still in school pursuing STEM related courses.

Study findings showed that women's success in STEM was influenced by various factors that reinforce each other at various levels including at the individual, family, societal and the work environment. At the individual level, personal capabilities and academic preparation influenced the choice of whether women pursued STEM related careers or not. The choice to pursue STEM related careers was further influenced by other women working in STEM who acted as role models. Factors at societal level played a significant role in influencing the choice and success of women pursuing STEM related careers. Patriarchal attitudes at a macro level affected the choice of women to pursue and succeed in STEM. The success of women already working in STEM was highly influenced by the work environment—the recruitment process, promotion and gender relations played a great role in women's success or failure in STEM. Policies to address the gender gap in STEM exist but they are rarely implemented.

There is need for a multipronged approach that addresses challenges that women face in their quest to pursue STEM courses and succeed while in practice. Approaches should pay attention to factors that affect women's success in STEM at the individual, family and societal levels, and the work environment. Policy and programmatic measures should be institutionalised to safeguard gender equity in STEM both in the education system and work places.
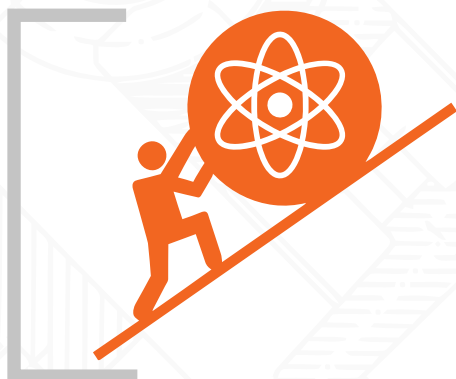
Study objectives

1 To identify the challenges and opportunities for women in STEM in Africa

2 Document experiences of women in STEM

3 Recommend ways of closing gaps

Chapter One: Introduction and Literature Review

Introduction

In 2015, countries that form the United Nations adopted the 2030 Agenda for Sustainable Development detailing an ambitious universal blueprint that comprises 17 goals and 169 targets. Innovation, science and technology is expected to play a significant role in meeting these goals [1]. A country's ability to secure good health, fight diseases, protect the environment, attain food sufficiency, and develop new industries and technologies relies on the scientific knowledge and skills of its people [2]. To achieve this, it is expected that countries create, apply and diffuse scientific and technological knowledge. Unfortunately, countries are not fully utilizing the potential of the entire population, including girls and women. Africa in particular continues to lag behind in the generation of the human technological capacity that impacts negatively on the economic development [2]. In the global south, between 60 to 90 percent of women engage in agricultural production activities and carry the primary responsibility of providing water, energy, sanitation and health care needs of their family and communities [3]. Yet, fewer women participate in science education and therefore have limited access to jobs in these fields, which are among the highest paying. Research shows that excelling in science and mathematics is a strong indicator of later earnings [4], with women in Science, Technology, Engineering, and Mathematics (STEM) jobs earning more compared to women in non-STEM jobs [5].

Global statistics show that although progress is being made to increase women's participation

60-90%
of women engage in agricultural productivities
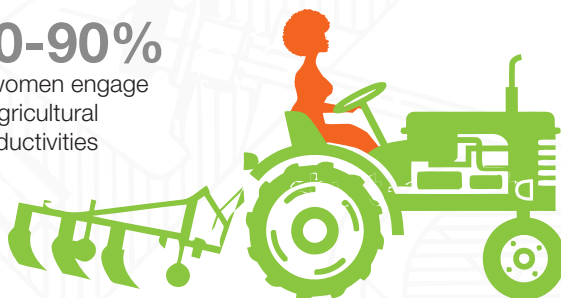
29%
of researchers globally are women

Excelling in science and mathematics is a strong indicator of later earnings

in many fields, however women still make up a minority of the world's workforce in STEM. For example, in 121 countries with available data, women make up 29 percent of science researchers [2]. Globally, men outnumber women as students, educators, researchers, and workers in STEM fields [1, 6], yet women scientists have an important role to play in Africa's development, including pushing the envelope on gender equality, one of the 17 Sustainable Development Goals (SDGs). There is significant progress made globally in closing the gender gap in primary school enrolment, however, gender inequality still prevails as well as acquisition of skill. In parts of Africa, there has been an impressive increase in primary school enrollment, but large numbers of children leave school without acquiring basic knowledge, skills and competencies [7]. About 45 percent of the 128 million children of primary school age in Africa are not learning basic literacy and numeracy skills after four years of school [2].

Actions are needed to narrow the gender gap in science to avoid loss of vast human resources that could contribute to national development and further perpetuate gender inequality. Persistent gender inequality severely limits women from achieving their potential and effectively contributing to development. Additionally, there is paucity of studies that have investigated why women continue to lag behind in job opportunities in the STEM sector.

Trends of participation of women in STEM

Women scientists have a vital part to play in scientific leadership and in contributing to Africa's development and transformation, but they remain substantially under-represented in higher education and in STEM. Available statistics show that the number of women in STEM is growing but the issue of gender parity remains elusive as men continue to outnumber women, especially at the upper levels of these professions. The 2015 United Nations Educational, Scientific and Cultural Organization (UNESCO) report provides an analysis of the gender gap in science and engineering. The report notes that women are

fairly well represented in some related science disciplines – including health, agriculture and environmental management [1], but are a minority in other fields such as energy, engineering, transportation, information technology and computing. These areas are vital for the actualization of the SDGs.

In the field of research, the report notes that women's participation globally reflects a typical leaky pipeline with women actively pursuing bachelor's and master's degrees where they outnumber men at these levels. Women represent 53% of graduates, but their numbers drop abruptly at PhD level—suddenly, male graduates (57%) overtake women [1]. The discrepancy widens further at the researcher level, with men representing 72% of the global pool. Latest data from UNESCO on Women in Science [8], show regional averages for the share of female researchers for 2015 accounting for 28% of global researchers (Figure 1). However, there are regional variations. For example, women are highly represented in Southeast Europe (49%), and in the Caribbean, Central Asia and Latin America (44%). In the Arab States women account for (37%), the European Union (33%) and the European Free Trade Association (34%), which are closely followed by sub-Saharan Africa (30%) [1]. Countries like Malaysia, the Philippines and Thailand have all achieved gender parity while in Africa, Namibia and South Africa are on the verge of achieving the gender parity. Countries with the highest proportion of female researchers are Bolivia (63%) and Venezuela (56%). Lesotho has dropped from 76% to 31% between 2002 and 2011. Between 2011 and 2013, there was an increase in the percentage of women researchers in South Africa (43·7%), Egypt (42·8%), Morocco (30·2%), Senegal (24·9%), Nigeria (23·3%), Rwanda (21·8%), Cameroon (21·8%), and Ethiopia (13·3%). However, there is still a high attrition rate in the number of women along the career trajectory in scientific research [1].

Data from some high-income countries indicate a low proportion of female researchers as well. For example, one in four researchers is a woman
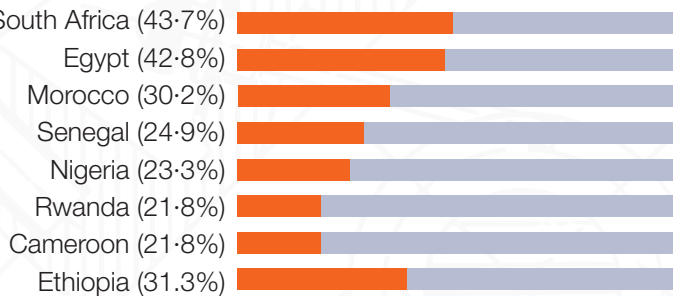
in France, Germany and the Netherlands. Even lower proportions are to be found in the Republic of Korea (18%) and Japan (15%). Japan has the lowest proportion of female researchers of any member of the Organization for Economic Co-operation and Development. The lowest participation rate of all comes from Saudi Arabia: 1.4% down from 18.1% in 2000. Participation is also very low in Togo (10%) and Ethiopia (13%) and has almost halved in Nepal since 2002 from 15% to 8% [1].

Major gender disparities between women and men research scientists are also evident in places of work and their levels of responsibility. Women scientists primarily work in academic and government institutions, while their male counterparts are engaged more in the private sector, with better pay and opportunities [9]. In addition, women scientists are often concentrated in the lower echelons of responsibility and decision-making with limited leadership opportunities. In academia, for example, women scientists are often lecturers and assistant researchers and very few are professors. In

research institutions, women are rarely research directors or principal investigators in major studies. In higher institutions of learning however, there is a global trend of gender imbalance in favor of female students in some regions. Female university students dominate in North America (57%), Central and South America (49–67%) and the Caribbean (57–85%). Europe and West Asia show a similar trend, with the notable exception of Turkey and Switzerland, where females make up around 40% of tertiary enrolment, and Liechtenstein (about 21%). In most Arab states, the trend towards gender parity is observed with the exceptions of Iraq, Mauritania and Yemen, where figures drop to 20–30%. Data from Morocco show a cyclical pattern from 2000 but a general rise to 47% in 2010 [1].

In parts of Africa, numbers are substantially lower, reflecting a gender imbalance in education at all levels. Female graduates at the tertiary level range from more than half in Namibia (58%) and South Africa (60%). Female representation has dropped substantially in Swaziland, from a high of 55% in 2005 to 39% in 2013. The lowest ratios of women

Percentage of women researchers in some African countries

South Africa (43·7%)
Egypt (42·8%)
Morocco (30·2%)
Senegal (24·9%)
Nigeria (23·3%)
Rwanda (21·8%)
Cameroon (21·8%)
Ethiopia (31.3%)

The lowest ratios of women to men tend to be found in low income countries

Women employed in R&D

Sub Saharan Africa (31.3%)
South and West Asia (18.5%)
North America and Western Europe (32.3%)
Latin America and Carribean (45.4%)
East sia and Pacific (23.4%)
Central Asia (48.1%)
Central and Eastern Europe (39.5%)
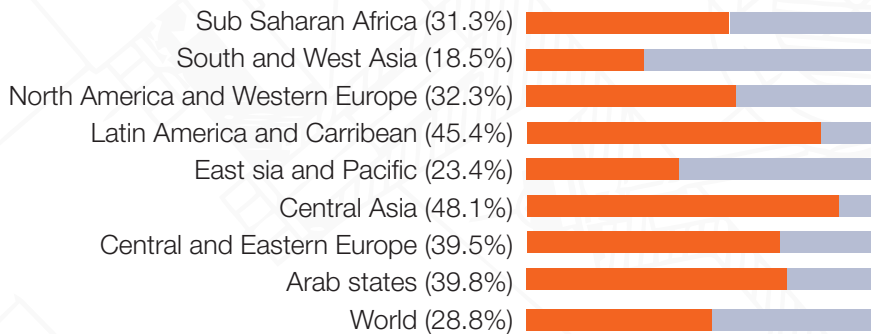Arab states (39.8%)
World (28.8%)

Figure 1: Share of Women in Research and Development

to men tend to be found in low income countries. Examples are Ethiopia (31%), Eritrea (33%), Guinea (30%) and Niger (28%). In Central African Republic and Chad, male tertiary students are 2.5 times more common than female ones. Notable exceptions among the 31 low-income countries are Comoros (46%), Madagascar (49%) and Nepal (48%) [1]. In South Asia, the participation of women in tertiary education remains low, with the notable exception of Sri Lanka at 61%. The gender inequity gets even worse in the transition to the workplace [10, 11]. Overall, women are more likely to pursue tertiary education in countries with relatively higher levels of national income.

Factors influencing women pursuing STEM

The central question is, why does the proportion of women in STEM-related professions fail to reflect the interest girls demonstrate for mathematics and science courses in early school years? Various factors have been documented as possible contributors to the gender discrepancy in STEM. These factors can be classified under the nature versus nurture debate. One of the assumptions under the nature argument is that girls' brains develop differently from boys', and that biological differences explain the gender gap in STEM [12]. This line of thought has been dismissed by those who argue that the evidence that biological factors cause gender differences in STEM is inconclusive [13]. Furthermore, there is evidence that in some countries, girls perform as well as or even better than boys in science [3].

There are many factors related to the nurture debate and its association with the observed gender differences in STEM. The most common

one is the negative stereotyping. According to Steele and Aronson [14], the stereotype threat negatively influences performance by shifting an individual's focus from performing a task to worrying that low performance will confirm a negative stereotype about a group to which the individual belongs. Research has consistently demonstrated that stereotype threat contributes to gaps in academic performance between races [14-16] and between women and men [15-17]. Negative stereotypes about the ability of girls to excel in STEM can substantially lower girls test performance and their aspirations for science and engineering careers over time [10, 18] yet men continue to outnumber women, especially at the upper levels of these professions. In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. Among first-year college students, women are much less likely than men to say that they intend to major in STEM. Children are socialized to learn about gender in early years in life as they encounter gendered roles and expectations [19]. Girls are therefore oriented to be communal (e.g., socially skilled and helpful), focus on children and family, and are more likely to be engaged in activities that emphasize interpersonal relationships [20]. Contrary, masculine gender role stereotypes orient boys to acquire mastery, skills and competence, explore the physical world, figure out how things work, and are likely to be involved in activities that emphasize problem solving, status, and financial gain [18]. It is therefore likely that masculine gender

roles align with popular cultural representations of STEM-related courses than feminine gender roles [21]. Research from multiple countries point to a trend where children often hold stereotypical views about STEM courses being for boys and non-STEM ones for girls [2].

Evidence from diverse bodies of research also show that social and environmental factors contribute to the underrepresentation of women in STEM [10]. In many African countries, sociocultural beliefs and practices largely connected to the construction of feminine identities, ideologies of domesticity and gender stereotypes may exclude girls from pursuing science subjects [22]. Sociocultural norms and gendered expectations about the role of females in society significantly affect girls educational opportunities, learning outcomes and decisions about study and work [2]. Research on the effects of societal beliefs and the learning environment on girls' achievements and interest in STEM shows that when teachers and parents interact with girls and support their effort, girls perform better in mathematics and are more likely to pursue math in the future [10].

Girls' self-assessment of their ability to succeed in STEM can play a significant role in whether they get enrolled for STEM courses or not. Research shows that girls assess their mathematical abilities lower compared with boys with similar mathematical achievements. In addition, girls are likely to believe that they must be exceptional to succeed in male dominated science fields [10]. A longitudinal study in the United Sates

assessed children's beliefs about their own academic competency and found that girls rated their mathematics ability lower than boys from an early age, even though no actual difference in math achievement exists at such ages [23]. These findings underscore the importance of self-confidence and its effect on the abilities of girls to pursue careers in STEM [13, 24].

Other studies have associated gender discrepancies in STEM with biasness and discrimination against women. Due to gender stereotyping, most people associate STEM with male and humanities and arts fields with female, and often hold negative opinions of women in masculine positions such as scientists or engineers. What this implies is that people are likely to judge women to be less competent than men in the so called male jobs unless they are exceptionally successful in their work [10]. In a randomized double-blind study, science faculty from research-intensive universities rated the application materials of a student who was randomly assigned either a male or female name for a laboratory manager position. Results showed that faculty members rated the male applicant as significantly more competent and hirable than the female candidate [25].

Other factors that have been documented to contribute to gender differences in STEM include women's general preference for non-STEM courses and negative attitude toward STEM that stem from the environment and social relations [2, 26], parents' expectations that socialize children's

Factors that contribute to under representation of women in science

Social and environment

Negative attitudes towards STEM

Bias and discrimination

Girls' low self assessment

academic trajectories [24], peer acceptance where same-sex friends' interest influences adolescent girls' pursuit of STEM [27], and inadequate academic preparation at lower levels of education for both gender [28].

The summary described above reflect the main contributors to the existing inequalities ranging from policy, institutional and individual factors that contribute to the underrepresentation of women in STEM. Many African countries, university departments and research institutes are often led by men who also occupy key leadership positions of responsibility. Persisting gender biases and stereotypes embedded within these institutions create an often-challenging work environment for women scientists. Moreover, lack of programmes to recruit women scientists, coupled with an undefined career path, and the absence of mentoring programmes within institutions to provide professional support, tend to make it difficult to attract and retain women scientists[29]. While many countries in parts of Africa have enacted Science, Technology and Innovation policies, some of which have gender-related objectives aimed at promoting women's participation in science, they are rarely implemented. Some examples of best practices for tracking and closing the gender equity gap in STEM in Africa have begun to emerge, which alongside structural change can help bring transformation.

Study Rationale

Globally, tremendous gains have been witnessed in the education and workforce. Nonetheless, progress has been uneven, and STEM disciplines remain overwhelmingly male dominated [10]. Even though the gender gap in STEM is narrowing, females continue to be less likely to pursue STEM careers compared to their male counterparts [26]. Various explanations have been advanced for the observed underrepresentation of females in the STEM fields [30-32]. There seem to be consensus

that there could be many factors that influence women to take up STEM courses and that biological or gender ability is not the overriding factor in the underrepresentation of females in math-intensive fields [26].

Whereas efforts have been made to recruit and retain more women in STEM, a stark gender disparity persists. It is clear that this inequity will not resolve itself solely by more generations of women moving through the academic pipeline [25]. There is need for efforts to close the gender gap in science to ensure that women as much as men benefit as citizens and contributors to their societies. There is no reason why women continue being passive users of science and technology. Deliberate efforts should be made to bring women to the table as active participants in scientific development, application and decision making. Indeed, the gender gap in STEM must be more effectively addressed to benefit both society and the individual. Undoubtedly, as women increasingly participate in STEM, their communities and nations will reap the benefits.

In view of these observations, the African Academy of Sciences conducted a study to assess factors contributing to or inhibiting women's careers in STEM in Africa. Specifically, the study aimed to identify the challenges and opportunities that women in STEM in Africa face through their career. The study aimed to provide empirical evidence, conceptual clarity and policy advice on the challenges and opportunities women in STEM in Africa face and how to address these challenges. The study also aims to contribute to efforts of reducing the gender gap by documenting strategies that are already in place or can be developed to improve participation of women in STEM. The study equally highlights policy, legislative and organizational initiatives that can significantly reduce the gender gap in STEM in Africa.

> *There seem to be consensus that there could be many factors that influence women to take up STEM courses and that biological or gender ability is not the overriding factor in the underrepresentation of females in math-intensive fields [26].*

Chapter Two: Study Design and Methods

The study was designed as a cross-sectional mixed method design to triangulate multiple data sources. We employed two-phase sequential approach where data collection was conducted simultaneously. Data gathering activities involved combining the strengths of multiple methods and using it for greater insights to develop a rounded and nuanced perspective on factors that facilitate or hinder women in STEM. The study was guided by the following questions:

i.   What are the facilitating and inhibiting factors for Women in STEM on the continent?

ii.   What are some of the illustrative examples or cases of local (grassroots), national, regional, continental and international initiatives/programmes that either directly or indirectly improve women in STEM careers and fields (with emphasis on Africa)?

iii.   What are policy, legislative and organizational initiatives that can significantly reduce the gender gap in STEM in Africa?

Data Collection Activities

Document review

We conducted a rapid scoping review of literature with the aim of understanding the status of women in STEM in Africa. This involved using various databases including Google Scholar, PubMed, Dryad, BioMed Central, Public Library of Science, arXiv e-Print Archive, Directory of Open Access Journals, ScienceOpen, and CORE. We also searched websites of organizations dealing with issues related to women in STEM and available data in the grey literature. In addition, we contacted organisations in Africa that focus on grass root efforts to document their initiatives to improving STEM. Data generated was used to provide a description of the policy landscape, strategies and interventions aimed at developing and building successful approaches towards ensuring women are involved in STEM in Africa.

Qualitative interviews with women in STEM

We interviewed various categories of women working in STEM including those in the academic environment (research institutes, universities, or other institutions of learning); women working in industry represented by the manufacturing or related science and engineering companies; and those working in international and national policy environment. Efforts were made to have different regions represented in Africa: Western, Eastern, Southern, Northern and Central Africa. Study participants were purposively identified to participate in in-depth interviews (IDI).

A total of 17 IDIs with women described above were conducted. Women in STEM were interviewed by research assistants with training in qualitative data collection using a guide. Information captured included women's general views on STEM, what facilitated or hindered their success in progression in the STEM field, policy implications and what needs to be done to improve women participation in STEM, and regional and global efforts to ensure women are included in STEM. The interviews were audio-recorded with consent of the participants and later transcribed verbatim.

Quantitative interviews with women in STEM

An online quantitative survey was conducted between October 2018- June 2019 among women in STEM from various regions in Africa. The tool was adapted from previous studies that have examined STEM issues. The tool covered issues such as demographic of women including level of education and field of science they are pursuing. The second section focussed on factors influencing women to pursue STEM related careers with a focus on issues that were identified in literature; patriarchal attitudes, values and beliefs; work related environment and its influence on excelling in STEM; experiences of women with regard to recruitment, renumeration and promotion; gender relations in the work

place; trainings skilled development and empowerment; women pursuing STEM related careers and its effect on family life. In addition, we sought to examine key facilitators of women who have excelled in STEM and what policy options may help support women to excel in STEM.

Our initial sampling aimed to represent various regions as well as sub sectors. Since, this study is not assessing issues of impact, pragmatic sampling process targeting a total of about 2000 women was adopted. To do this, a two-stage sampling procedure was used. First, a list of all possible institutions was developed representing various regions for each category. This provided the first stage of sampling. Thereafter, we sent out invites to all institutions identified for participation. From the invites, a subsequent follow up was made on email and using various networks and social media to encourage women to participate in the survey. Before administering the questionnaires, the content of the study and the eligibility criteria was explained to the participants via email and an online informed consent was sought from the participants. A self-administered tool was then sent to all potential study participants online. Due to the slow nature of response, we adopted a paper tool for about 50 participants to build the numbers which was later entered onto the online platform. The criteria used to establish eligibility of study participants were willingness to participate in the study, consent and working or pursuing a career in STEM. The survey sought to gather information on respondents' demographics, what factors they considered important in supporting or hindering women from pursuing STEM in Africa, and their knowledge and attitudes towards policies aimed at supporting women pursuing STEM.

Data Processing and Analysis

As qualitative research can easily produce a voluminous amount of text, careful attention was accorded to data management. Research assistants were trained to encode notes

in two forms: 1) encrypting devices, used to hide information concerning informant identity and specific locations; and 2) indexing devices, which categorize subjects and type of interview. Notes were translated and linked to a database management program (Nvivo 12). Audio recordings of in-depth interviews were transcribed verbatim. In reviewing text data from interviews, inductive analysis was used to identify themes and patterns and construct typologies. Codes corresponding to themes and constructs were entered into the database and used to organize data for refined analysis. The principal investigator (PI) and other members of the data analysis team independently coded the first four transcripts which were compared, and differences reconciled. The data analysis team met regularly to discuss, add new codes or sub codes, and to identify emerging themes.

Analysis of quantitative data entailed descriptive statistics (frequencies and percentages). For data that sought to examine various experiences of women and its influence on excelling in STEM, we present both descriptive statistics and a summative score that summed experiences of women from questions that had up to five options ranging from strongly agree representing option 1 to strongly disagree represented by 5. For the scores generated, a negative binomial regression was conducted to examine the relationship between the scores that ranged from lowest score to highest possible score indicating a continuum from strongly agreeing with the constructs asked to high scores that represent strong disagreement with the constructs examined for various issues. The scores were regressed with various covariates such as employment status, age, marital status and level of education. Data is presented as incidence rate ratios with the p values and the confidence intervals.

Chapter Three: Results

Characteristics of respondents

A total of 415 respondents who responded to the online survey were used for this analysis out of which 396 completed the survey indicating 95.4% response rate. The respondents were on average aged 36 years (SD 8.7) with the largest category of respondents being 25-45 years. Over two thirds were employed with most of them on full time basis (69.2%). Table 2 shows that 46% were single and nearly the same percentage were married in monogamous relationships. Nearly 41% of the participants had at least Master's degree while a third were undergraduate students. PhD holders were 15.4%, while 7.8% were post-doctoral students. About 7% were diploma level holders.

Majority of the respondents who completed the survey were from Kenya (55%) followed by South Africa (12%), Nigeria (8.2%) and Uganda (6.4%). There was limited participation from French speaking countries. Although the numbers were small, there was good representation from the African regions. Eight countries participated from the Southern African region, seven from Western and Eastern African region respectively, two from Central Africa and the Indian Ocean islands respectively and one from North Africa. In terms of type of institutions represented in the study sample, nearly 35 percent of the study sample were based in higher education followed by public organisation (15.9%), with industry represented by less than two percent. Research agencies were represented by about 25% while private sector business enterprises were represented by 9%. Figure 2 shows that 40% of the respondents are working in the health sector while nearly a third (27%) are in the biological sciences. About 6% hold managerial positions in the STEM related fields and social sciences was represented by 9% of all respondents.

Table 1: Characteristics of respondents

Characteristics	415	(%)	Religion	396	
Willing to participate	396	(95.4)	Christian	354	(89.4)
Age	**396**		Muslim	20	(5.1)
19-24 years	34	(8.6)	Hindu	4	(1.0)
25-35 years	179	(45.2)	No religion	14	(3.5)
36-45 years	136	(34.3)	Buddhist	3	(0.8)
46-65 years	47	(11.9)	Jewish	1	(0.3)
Current Employment status	**396**		**Marital status**	**395**	
Employed	305	(77.0)	Single	183	(46.3)
Student pursuing STEM related courses	91	(23.0)	Married monogamous	179	(45.3)
Nature of engagement	**305**		Married polygamous	6	(1.5)
Contract basis	67	(22.0)	Divorced/separated	16	(4.1)
Full time	211	(69.2)	Widowed	8	(2.0)
Independent consultant	12	(3.9)	Living with partner	2	(0.5)
Intern	5	(1.6)	Religious Nun	1	(0.3)
Part time	10	(3.3)			
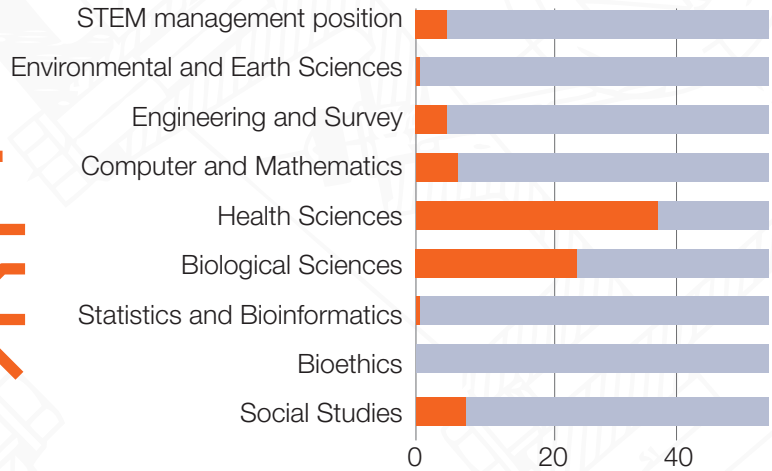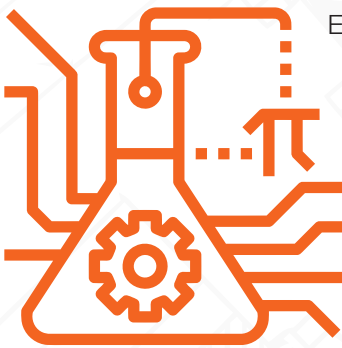
Figure 2: Field of Science represented by study sample

Facilitating factors influencing women in STEM

Individual level influences to pursue STEM related careers

Both qualitative and quantitative data point to several sources of influence to pursue STEM related careers. Figure 3 summarises quantitative data based on multiple responses on what influenced women to pursue STEM related careers. At the individual level, personal capabilities (61.1%), parents (26%), academic preparation (26%) and women role model (24%) contributes towards the choice's women make to pursue STEM related careers.
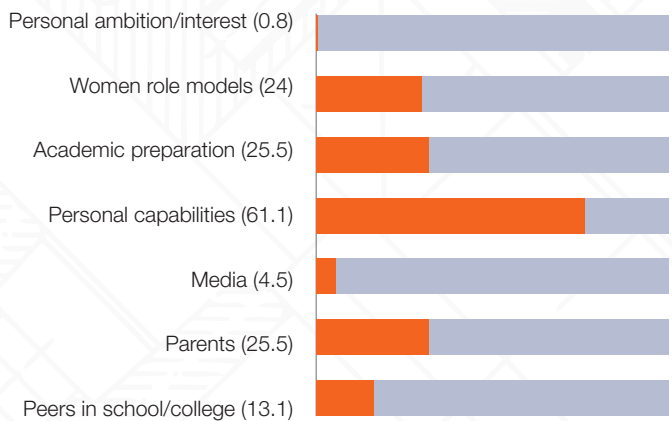
Figure 3: What influences women to pursue STEM related careers

The role of women role model and mentor in the family and environment was underscored in the qualitative results which demonstrated how successful women in STEM were influenced by close family circle to pursue STEM: "*It was the influence from my auntie… she is paediatrician and then her husband is a gynaecologist and my grandmother was a nurse. So, maybe that is why I decided to become a doctor… but I decided to become a medical doctor like when I was two years old.*" IDI, Botswana

To build on the issue of personal capabilities further, women were asked what attracted them to STEM career. Data in figure 4 are based on multiple responses, which show that 76 percent reported that the STEM careers fits their capability. The need for higher salaries (16.5%) or job security (24.2%) did not seem to feature as the main attractions to STEM. However, there were qualitative views suggesting renumeration in terms of financial benefits as one reason why they were motivated to pursue STEM courses. This view came from those working in public sector who believed that professionals in STEM were well compensated and therefore taking up a STEM course was a guarantee to better pay later in life. *"I was told I would be paid well if I take a STEM course."* IDI, Kenya

Another reason for pursuing STEM was curiosity. Being curious about how systems function and how machines operate was a motivating factor for some ladies to pursue STEM courses. Others were intrigued by nature and the challenges involved when studying sciences which kept them on their toes wanting to learn more.

Although passion was mentioned in less than two percent in the quantitative survey as shown in Figure 4, discussants in qualitative data mentioned that passion was a factor that motivated them to pursue STEM. Among those who made up their mind way back that they wanted to pursue STEM, they had the desired course at heart and had resolved to succeed no matter how tough the course was. Other respondents were passionate about STEM because the topics taught were straight forward and predictable: *"I was passionate about it [STEM]. So, it didn't bother me… some of these challenges made it quite all right with me. My passion kept me going because I didn't see myself elsewhere, I didn't see myself doing something else, so I had to pursue it regardless.*" IDI, Nigeria

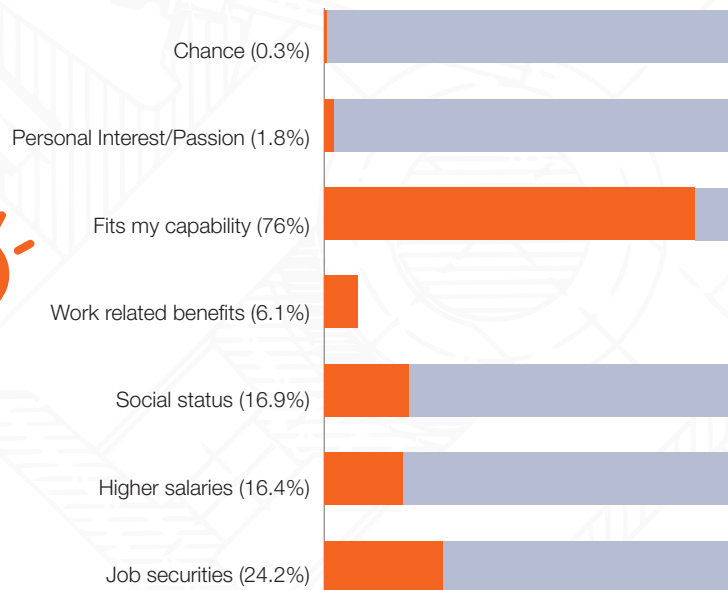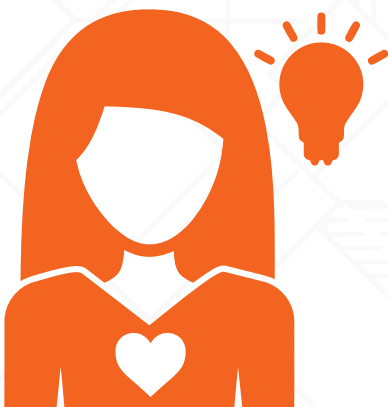Passion is further augmented with family level support, where for example, 74 percent of

Figure 4: Attraction to STEM related careers

the respondents reported that their family reacted positively by supportng their decision to pursue STEM related careers, 2.8 percent were highly negative, while seven percent were not supportive. From the above syntheses, two main factors appear to influence women to pursue STEM from the individual level and are instrumental in the choice's women make to pursue STEM. First, is belief in personal capabilities to manage STEM related courses, two is the role of women and mentors at family level and the environment which seems to facilitate choice of career in STEM.

What influences women to excel in STEM related careers

Discussions on what facilitates women in excelling in STEM is presented in Table 3 and subsequently we discuss issues raised from the female perspectives that can ensure women excel in STEM. Analysis of the quantitative data is based on two sets of analysis a descriptive analyses describing the proportion that considered the factors highlighted in table 4 as a facilitator to excel in STEM. The second set of analysis is based on generating a single score from the Likert scale ranging from 1 which represent a factor being not a facilitator to 4 indicating a major facilitator. This analysis generated a continuous variable with lowest sum indicating the factor is not a facilitator while the highest score indicates the degree to which the issues are a major facilitator. These scores are then subjected to negative binomial regression model against various covariates to examine their relationship between degree of facilitation and various demographics. In all the elements asked, survey participants reported in over 80 percent to the affirmative that the elements facilitate women to excel in STEM. The role of mentors, (95.2%), opportunity for training (96.2%), funding for innovation (94%) and existence of pregnancy leave policy (91.4%) were factors that were also mentioned during qualitative discussion presented below. From regression analyses it was evident that women who are employed were more likely to report that the combined elements are a major facilitator to make women excel in STEM: IRR: 1.05, P=0,023; (95%CI: 1.0, 1.11). There were no other associations with all other covariates.

> " *I was passionate about it [STEM]. So, it didn't bother me…some of these challenges made it quite all right with me. My passion kept me going because I didn't see myself elsewhere, I didn't see myself doing something else, so I had to pursue it regardless.– IDI, Nigeria*

Table 2: Facilitators for women who have excelled in STEM

% of respondents who identified the following as facilitators for excellence in STEM	396	(%)
Presence of mentors and role models	377	(95.2)
Supervisor support	376	(94.9)
Negotiability of work schedule	353	(89.1)
Quality of communication	368	(92.9)
Opportunity for training	381	(96.2)
Availability of funding for scholarship	372	(93.9)
Availability of funding for research & innovation	373	(94.2)
Opportunities for leadership development	379	(95.7)
Opportunities to network	378	(95.5)
Opportunities for professional development	381	(96.2)
Giving hiring preference to under-represented group members	339	(85.6)
Hiring based on ability of candidate to meet job requirements rather than personal preferences	375	(94.7)
Active recruitment of diverse	361	(91.2)
Hiring based on knowledge, skill, and ability to perform job rather than irrelevant personal characteristics	381	(96.2)
Covering responsibilities for women with new-child leave with compensation	359	(90.7)
Existence of pregnancy leave policy	362	(91.4)
Availability of childcare	345	(87.1)
Salary compares to similar organizations	353	(89.1)
Administrators ensuring policies and practices are implemented without bias	369	(93.2)
Transparency in communication	367	(92.7)
Availability of appropriate role models	371	(93.7)
Support of colleagues at workplace	368	(92.9)
Average score of 23 Items with a range of 1-4 scores (SD)		
Relationship between summative scores for perceptions on family with covariates		

Covariates	IRR	P value	95% CII)
Employment status	1.05	0.023	(1.00,1.11)
Type of organization: ref: Private			
Research agencies	1	0.879	(0.95,1.05)
Public agency	0.997	0.931	(0.93,1.05)
Higher education	1.01	0.533	(0.96,1.07)
Level of education: Ref: undergraduate and below			
Postgraduate	0.984	0.491	(0.94,1.02)
Age category: Ref: 19-24 years			
25-35 years	1.06	0.126	(0.988,1.1)
36-45 years	1.06	0.151	(0.97,1.15)
46-65 years	1.03	0.5	(0.94,1.13)
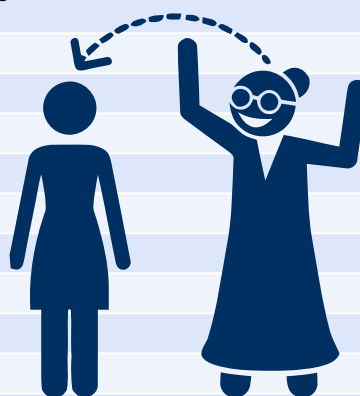
Post estimation of age groups	P values
25-35 vs 36-35 years	0.929
25-35 vs 46-65 years	0.398
36-45 vs 46-65 years	0.363
Between all three age groups	0.375

From the qualitative data discussants identified six main factors that facilitate women to excel on STEM:

i. *Availability of equipment and resources*

Study participants attributed their success in STEM to availability of resources when they were undertaking their respective courses. This included well-stocked libraries that would offer books to read and access to internet where they could quickly find information. Since most of the STEM courses involve use of laboratories, existence of such facilities also made it easier for students to complete their practical assignments: *"Having a good system like libraries, having access to library books, having access to the internet… Also, just having supportive classmates; we used to do a lot of work in groups. Having also a good laboratory back in JKUAT. There was a very good laboratory to carry out the science practical."* IDI, Kenya

ii. *Empowerment*

Table 3 shows that aspects of empowerment of girls either through financial support or ensuring that female students were equally treated as their male counterparts was helpful in facilitating success among women in STEM. Affirmative initiatives such as payment of school fees for girls was necessary in enabling girls complete their education. Offering girls advice and direction regarding STEM-related career

path was important in ensuring that women succeeded in STEM: *"What we are doing as an organization through the different projects we are undertaking, we decided to leverage on school fees, by paying for their school fees and by so doing more girls are completing school because we are supporting them in school. We are also giving them more knowledge on careers which they want to take…we provide knowledge and some direction…we take them through the curriculum so that the girls are able to be given direction."* IDI, Zambia

iii. *Family support*

Support from family members was mentioned as a factor that propelled women to succeed in STEM. This included support from members both in the nuclear and extended families who were either working in STEM related fields or family members who provided material support or encouragement to women undertaking STEM courses. Parents who encouraged their children to pursue whatever course they wanted at the college level were also mentioned as critical in aiding women succeed in STEM.

iv. *Peer-to-peer support*

Study participants were of the view that the support from peers undertaking the same course was key in enabling them to succeed in STEM. Peer support from student of the same or different gender was handy especially when working on assignments. Support from male

By paying for their school fees […] more girls are completing school because we are supporting them in school

students seemed to be key in ensuring that female students completed their STEM courses.

v.   Scholarships

Over 95% of the survey respondents reported that scholarship was a crucial facilitator for success in STEM (Table 4). Support in terms of financial resources was highlighted by interviewees as a significant factor in ensuring that women were successful in STEM. This was mostly in form of financial support through payment of school fees for girls at lower levels of education to ensure that they transit to the next level. Support in terms of knowledge and advice on STEM courses was also offered to encourage girls to take up STEM courses. At the university level, scholarships offered by science and technology universities were vital in facilitating girls towards successful completion STEM courses.

vi.   Support from teachers

Support by teachers, especially those teaching mathematics at lower levels of education was mentioned as an important factor that enabled girls develop an interest in STEM related careers. Supportive lecturers at higher levels of education were also mentioned as individuals who played a key role in ensuring that women succeed in STEM. The support from teachers was mainly in form of encouragement to the girls and letting them know that they had the potential to succeed just like their male counterparts:

"The first year, I talked to the mathematics teacher and I told him that you know I really need help because I'm not good at mathematics and he told me that, you are good at mathematics and you are going to show this to me. And there I was…I had one of the best marks! And I went to him I said, "thank you very much" and he said, I told you, you are good, and you will make it you know. See the difference." IDI, Botswana

Barriers and challenges facing women in STEM careers

The second objective was to address what barriers, challenges and opportunities women in STEM in Africa face through their career and how to address the challenges. First, we examined why there are few women pursuing STEM related careers based on multiple responses. Table 4

highlights some of the individual level factors that inhibit women form pursuing STEM. Family focussed issues appear to dominate the reasons behind few women in STEM. For example, family responsibilities reported by 57 percent of the respondents and difficulty in finding work-life balance (50%) were the common reasons why there are few women pursing STEM. Additionally, difficulty in securing positions in the same geographical area as their partners (37%) and the perception that women are perceived less competitive (39%) topped the list of reasons.

Table 3: Reasons for few women in STEM
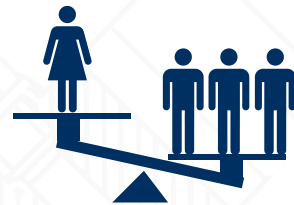
Reasons for few women STEM	396	(%)
Gender differences-mathematical/biological	127	(32.1)
Family responsibilities	225	(56.8)
Women are perceived less competitive	157	(39.6)
Qualification of women compared to men	95	(24.0)
Perceived lack of commitment among women	123	(31.1)
Men are favored by workplace environment	128	(32.3)
Fewer opportunities for women compared to men for advancement in STEM	143	(36.1)
Masculinity associated with creativity	89	(22.5)
Preference for flexible work conditions	144	(36.4)
Difficulty in finding work-life balance	200	(50.5)
Difficulty in securing positions in the same geographical area as their partners	149	(37.6)

At societal level, other issues that may inhibit women from pursuing STEM careers are linked to patriarchal attitudes which inhibit women pursing STEM related careers. Table 5 for example shows that over two thirds (72%) of all

respondents agreed that majority of girls prefer to study arts subjects and the softer sciences such as biology and geography while 76% agreed that discrimination of women in decision making positions may discourage women from pursuing STEM careers. Seventy three percent agreed that hegemonic masculinity influenced by socio-cultural values and beliefs impacted women in STEM.

Table 4: Patriarchal attitudes, values and beliefs

% of respondents who agreed that	396	(%)
Negative traditional beliefs that women are inferior to men are contributing to girls'/ women's lack of enthusiasm for STEM in secondary and tertiary studies	298	(75.3)
Majority of girls prefer to study arts subjects and the softer sciences such as biology and geography	284	(71.7)
Traditional perceptions that "a woman's place" is not the hard sciences	287	(72.5)
Hegemonic masculinity influenced by socio-cultural values and beliefs plus organizational gender inequality perceptions among both males and females affect women in pursuing STEM	287	(72.5)
Sexism and stereotyping of women's roles	312	(78.8)
Casting females into supportive roles due to socio-cultural norms	321	(81.1)
Patriarchy is responsible for the masculine image of STEM	252	(63.6)
Discrimination for women in accessing decision making positions	300	(75.8)

The third set of factors that inhibit women in pursuing STEM is work related practices. Table 6 outlines two sets of areas. One is around workplace environment and the second is recruitment and promotion. Responses to these issues were based on a Likert scale ranging from 1 which represent strongly agree to 5 which represent strongly disagree. Two sets of analysis were conducted, first we describe the individual responses in terms of the proportion that agreed with each of the constructs. The second set of analysis generated a single score from summing all the elements from each subcategory which denotes a continuous variable with lowest sum indicating levels of agreement and higher scores indicating higher levels of disagreement with the constructs tested. These scores are then subjected to negative binomial regression model against various covariates to examine their relationship between levels of agreement with various demographics.

In the work environment, participants reported that 61% agreed that they constantly need to prove themselves that they are capable as men while nearly 80% of women deal with obstacles that men don't. Nearly 70% agreed that there are false perceptions on women scientist suitability. These high rates of response on these elements suggest potential role of stereotypes that women face in the work environment as they pursue STEM careers. Overall, work environment experiences scored an average of 32.1 (SD: 9.6) from an expected range of 12 being the minimum level of strong agreement to 60 which is a maximum level of disagreement (Table 6).

While examining issues of recruitment and promotion, most women (90%) agreed that they were recruited on merit, but only about 56 percent reported that they are sufficiently rewarded based on their academic and professional qualification. Women also seem to agree that men in STEM have more career opportunities than their women counterparts (60%), which speaks to the potential challenges of beliefs of men being favoured in workplaces. It is also important to note that reported level of sexual harassment during recruitment or promotion was less than 12%, despite subtle responses from qualitative data that suggested various forms of sexual harassment as discussed later in the barriers section.

Table 5: Experiences Related to the Work Environment

Work Environment related experiences		
% of respondents who agreed that	396	%)
Working conditions consider that you are a scientist and a woman	204	(51.5)
More preference given to males in the organization (regarding recruitment and promotion)	199	(50.3)
My position is more challenging for a woman	159	(40.2)
I constantly need to prove myself that I am capable as the men	240	(60.6)
The working environment is stressful to me as a woman	148	(37.4)
Working environment is more suitable for men than women	167	(42.2)
Women deal with obstacles that men don't	315	(79.5)
As a woman I sometimes feel marginalized	222	(56.1)
Work environment has excellent career opportunities in STEM but entry by women is slim	228	(57.6)
There are false perceptions on women scientist suitability	275	(69.4)
There exist discriminatory and violations of Women's rights in the workplace	169	(42.7)
Limited advancement opportunities	223	(56.3)
Average score of 12 Items with a range of 1-5 scores (SD)	**32.1**	**(9.65)**
Experiences regarding recruitment, renumeration and promotion		
% of respondents agreeing with the following statements	**396**	
I am sufficiently rewarded according to my academic and professional qualification	219	(55.3)
I was recruited on merit	357	(90.2)
Men are more easily promoted than women	190	(48.0)
Men in the STEM have more career opportunities than their women counterparts	237	(59.8)
I encountered sexual harassment during recruitment exercise	43	(10.9)
I encounter sexual harassment during promotion exercise	45	(11.4)
Female have high chances of job retention during downsizing of organization	94	(23.7)
In the process of organizational growth, development and expansion, women feature significantly in the workforce projections	163	(41.2)
Male perceptions that females always underperform is valid	69	(17.4)
Females are a burden to organizations due to their family and reproductive role	94	(23.7)
Average scores of 10 items with a range of 1-5 scores (SD)	**31.3**	**(5.84)**

Table 7 provides data on the relationship between the summative scores on both work environment and recruitment process. Using negative binomial regression model. Women were more likely to disagree with the statements on work environment if they were employed compared to those who are not with an Incidence Risk Ratio (IRR) of 1.1, p=0.005, (0.99,1.16). Similarly, women working in research agencies were more likely to disagree with the construct on work environment compared to those in private agencies; IRR 1.09, P=0033 (1.02, 1.2). The same trend was also observed with the relationship between summative scores of the process of recruitment and promotion. Post estimation analysis indicate differences in age groups that are above 25 years.

Table 6: Relationship between work experiences with demographics

Relationship between summative scores for Work Environment with covariates	IRR	P value	95% (CII)
Employment status	1.07	0.055	(0.99,1.16)
Type of organization: ref: Private agencies			
Research agencies	1.09	0.033	(1.0,1.2)
Public agency	1.03	0.498	(0.93,1.13)
Higher education	1.0	0.842	(0.92,1.09)
Level of education: ref: undergraduate and below			
Postgraduate	0.96	0.316	(0.90,1.03)
Age category: Ref: 19-24 years			
25-35 years	1.02	0.48	(0.91,1.1)
36-45 years	1.02	0.37	(0.89,1.16)
46-65 years	0.9	1.38	(0.77,1.0)
Post estimation of age groups	**P values**		
25-35 vs 36-35 years	0.902		
25-35 vs 46-65 years	0.009		
36-45 vs 46-65 years	0.012		
Between all three age groups	0.056		
Relationship between summative scores for recruitment, renumerations with covariates			
Employment status	1.06	0.007	(1.1,1.11)
Type of organization: ref: Private agency			
Research agencies	1.08	0.002	(1.03,1.1)
Public agency	1.05	0.071	(0.99,1.11)
Higher education	1.06	0.23	(1.0,1.11)
Level of education: Ref: undergraduate and below			
Postgraduate	0.98	0.467	(0.94,1.0)
Age category: Ref: 19-24 years			
25-35 vs 36-35 years	0.809		
25-35 vs 46-65 years	0.011		
36-45 vs 46-65 years	0.074		
Between all three age groups	0.011		

From the above analysis four things stand out. First it appears like stereotypes around desire for women to prove themselves, various obstacles women face as well as their perception of suitability as scientists may inhibit them to advancing their careers in STEM. The second aspect that seem to be perpetuated is the need for equality in the reward system. Although women get recruited on merit, about 56 percent are not remunerated as per their qualification. Thirdly, women who are working especially those in the research environment seemed to disagree with most of the statements meaning that there may be some changing

trends on how women are treated in the work settings. Finally, differences in age categories may be masking the relationship dynamics in the work place, Table 7 shows that a third of the respondents agreed that organizations they work with attained gender parity in its work force (that is, the percentage of female workers in the organization equal to that of males). There seem to be gender inequities advanced in workplace that is reflected in the low percentages of women who agreed with statements such as female scientists are not taken seriously (37.4%); There is evidence of gender parity and equality during recruitment and access to decision making levels (47%).

A further analysis of the role of gender relation construct and covariates shows that women working in a research settings were more likely to disagree with the statement provided compared to those working in the private sector; IRR: 1.1; P=0.003 (95% CI: 1.03, 1.2) perhaps indicating a vibrant work setting where gender issues are taken seriously. In addition, if you consider age categories, women who are in their middle ages of between 25-35 years and those between 36-45 years are more likely to disagree with the statements on gender issues compared to the younger ones: IRR: 1., P=0.05, (1.0,1.21), and IRR: 1.14, P=0.016; (1.02, 1.26) respectively. This perhaps indicate that the middle-aged women may well be the verge of overcoming gender disparities in the workplace.

Table 7: Women experiences regarding gender relations

% of respondents agreeing with the following statements	396	
Organization attained gender parity in its work force(that is, is the % of female workers in the organization equal to that of males)	125	(31.6)
Societal value on woman result in gender blind policies and procedures used in the workplace	225	(56.8)
I feel comfortable working with male scientists as colleagues	335	(84.6)
I do not feel comfortable working with male colleagues	57	(14.4)
Female scientists are not taken seriously	148	(37.4)
Female scientists working in STEM are treated as intruders in a male domain	138	(34.8)
Males are taken more seriously during professional discussions/meetings	236	(59.6)
Masculine image of the sciences, engineering, and technology prevails	283	(71.5)
Gender insensitivity governs recruitment, remuneration and promotional procedures exist in my workplace	156	(39.4)
Gender discriminatory practices based on acceptance of male dominance and female subordination within the workplace exist	175	(44.2)
There is no gender mainstreaming in operational tools	144	(36.4)
There is evidence of gender parity and equality during recruitment and access to decision making levels	186	(47.0)
Average scores of 12 items with a range of 1-5 scores (SD)	**34.2**	**(8.2)**
Relationship between summative scores for gender relations with covariates		
Covariates	**IRR**	**95% CII)**
Employment status	1.03	(0.97,1.1)
Type of organization: ref: Private		
Research agencies	1.1	(1.03,1.18)
Public agency	1.03	(0.95,1.11)
Higher education	1.03	(0.96,1.1)

Level of education: ref: undergraduate and below		
Postgraduate	0.98	(0.92,1.04)
Age category: Ref: 19-24 years		
25-35 years	1.1	(1.0,1.21)
36-45 years	1.14	(1.02,1.26)
46-65 years	1.08	(0.96,1.22)
Post estimation of age groups	**P values**	
25-35 vs 36-35 years	0.238	
25-35 vs 46-65 years	0.679	
36-45 vs 46-65 years	0.213	
Between all three age groups	0.0945	

Qualitative data illustrate in detail some of the factors that may hinder women to advance in STEM. From the qualitative data analysis, a synthesis of why women are few in STEM are highlighted in table 8. They are clustered in eight thematic areas which resonate with the barrier that inhibit women to pursuing STEM. details of each theme are discussed below.

Table 8: Qualitative summary of why women are few in STEM

Individual level reasons
1. Perceived lack of commitment among women.

Academic related
1. Qualification of women compared to men.
2. To stay in STEM course requires a lot of hard work and extra hours of dedicated studying.
3. The teachers do not simplify the lessons.
4. STEM courses are difficult for a lot of girls to cope with.
5. The mindset of the girls/women themselves regarding STEM right from when they are still in school.

Job attributes/work related
1. Difficulty in finding work-life balance.
2. Demanding schedules for STEM related careers
3. Preference for flexible work condition
4. unsupportive work environment
5. Men are favored by workplace environment

Gender stereotypes
1. Gender differences-mathematical/biological.
2. Women are perceived less competitive.
3. Masculinity associated with creativity
4. Patriarchal perception of STEM careers

Self-doubt/Confidence
1. Not believing that they can do it.
2. Lack of self-confidence.
3. Self-imposed fear of STEM.

Opportunities
Fewer opportunities for women compared to men for advancement in STEM.

Societal expectations
1. Fear of not conforming to traditional societal views.
2. Preferential treatment for men and sexual harassment

Family Level support
Difficulty in securing positions in the same geographical area as their partners.

Job related attributes

i.   Demanding schedules for STEM related careers

Discussants noted that the nature of science related careers are demanding which makes it hard to either start or maintain the family with the schedules at work. There are instances where collaborative linkages call for international travel either for conference or meetings across the globe which makes it hard for women to manage especially if they already have a family. The balance between deciding to start a family or manage a young family with the careers makes it hard for women to pursue STEM as demonstrated in the quote: *"If you have a young family that is not practical, that is not even possible. Yeah so, then things like conferences and seminars that were held out of town automatically it is just hard to travel, because you are thinking you have got this new baby, you are breastfeeding, how do you travel with the baby, then you have to travel with the nanny, and I remember one of our classmates actually had an argument with her husband. We had this conference in 2013 December and the husband would not believe that it is a conference that is taking her away, so he forbade her from attending it."* IDI**.** Working in STEM sometime requires long hours of work with complex schedules that oftentimes interfere with family roles and arrangements. For example, those working in laboratory sciences may require working late and this leaves them vulnerable in balancing work-life relationships.

ii.   Unsupportive working environment

There were discussions of how the working environment limited women pursuing STEM. Female employees have challenges getting time off work to manage sick children or perform certain family functions during work hours without feeling intimidated by the employer.

"If you have kids and you have to go to hospital, having that off day is very hard. You can actually lose your job if you have several kids and maybe they get sick, one at a time, you know, different times, but if it is one kid probably occasionally. But if you have like three kids, you can imagine how many sick offs you'll have to take." IDI.

Work related activities do stop women from advancing as most of them (68-73%) reported that aspect such as travelling and work-related tasks affected their family. This reinforces the fact that family matters significantly influence women's advancement in STEM careers. Table 10 focus on two main aspects of work environment; training and skills development as well as the relationship between work and family and how that affects advancement in STEM career. It appears from the data that professional growth of females are not highly prioritised as indicated by what proportion agreed that the organization, they work send women for training, skill advancement and empowerment every year (29%), 60% of women reported that they are given resources and training to do their work. The work-family balances appear to be affected by several issues such as negative perceptions of the place of women with 82% reporting that it affects the pursuance of STEM. In addition, time to set up family as well as the fact that the family suffers to work related responsibilities were reported as factors that limit career advancement as indicated in table 5; 80% and 70% respectively.

A further analysis between the scores presented in table 10 and the covariates show that there no associations between the covariates and the scores (table 11)

Finally, unfriendly workplaces which was sometimes characterized by unsupportive team leaders makes it hard for women to remain in STEM. There are certain jobs that require protective equipment or special gear for female employees to be comfortable. Lack of such gadgets made it hard for them to perform equally well as their male counterparts.

Self-doubt and confidence

i.   Self-doubt, societal expectations

Women may have some form of self-doubt that may inhibit them from pursuing STEM courses as was expressed by a participant:

"One of the barriers is you don't believe you can do it. Because the first time I was told I'm going to do the course I used to ask them, will I really manage? Uh, eventually I agreed. And, funny enough I passed because we have GPA system and the first GPA that I got I was like wow! It is doable. I never thought it could be actually very doable." IDI. The self-doubt may be enhanced by religious beliefs and/or cultural perspectives that continue to perpetuate the fact that men are supposed to work hard, and women are expected to get married.

Table 9: Women's experience on training and implications for STEM

Experiences on Training and skills development		
% of respondents agreeing that	**396**	**(%)**
Female scientists are given the resources and training to do the work	238	(60.1)
Female scientists are offered equal and adequate opportunities for professional development	216	(54.5)
Females are given work assignments that demonstrate their capabilities	243	(61.4)
There are excellent career advancement opportunities in the organization for women	199	(50.3)
Compared to males, professional females are sent by the organization for training, skill advancement and empowerment every year	116	(29.3)
Average scores of 5 items with a range of 1-5 scores (SD)	13.4	(4.5)
Experiences on implications of Career in STEM in the family life		
% of respondents agreeing that	396	
Society has a negative perceptions regarding the "woman's place	326	(82.3)
Reproductive phase such as maternity leave childcare limit career advancement among women	319	(80.6)
Family suffers due to work related responsibilities	278	(70.2)
Family suffers due to work related traveling	288	(72.7)
There is adequate study leave given to both female and male	211	(53.3)
Overtime creates a tough work-life balance for women	292	(73.7)
Women career suffer due to caring for the sick	242	(61.1)
Average scores of 7 items with a range of 1-5 scores (SD)	15.2	(4.8)
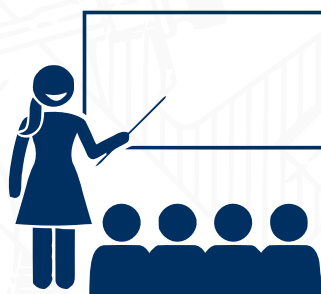
One of the barriers is you don't believe you can do it. Because the first time I was told I'm going to do the course I used to ask them, will I really manage? Uh, eventually I agreed. And, funny enough I passed because we have GPA system and the first GPA that I got I was like wow! It is doable. I never thought it could be actually very doable – IDI.

Table 10: Relationship between gender scores and training skills with covariates

Relationship between summative scores for training skills with covariates			
Covariates	IRR	P value	95% CII)
Employment status	1.05	0.263	(0.96,1.14)
Type of organization: ref: Private			
Research agencies	1.001	0.971	(0.91,1.10)
Public agency	1.003	0.944	(0.90,1.11)
Higher education	0.998	0.809	(0.89,1.08)
Level of education: ref: undergraduate and below			
Postgraduate	1.02	0.472	(0.95,1.11)
Age category: Ref: 19-24 years			
25-35 years	1.07	0.275	(0.94,1.23)
36-45 years	1.06	0.373	(0.92,1.24)
46-65 years	1.15	0.08	(0.98,1.36)
Post estimation of age groups	P values		
25-35 vs 36-35 years	0.848		
25-35 vs 46-65 years	0.198		
36-45 vs 46-65 years	0.159		
Between all three age groups	0.317		
Relationship between summative scores for perceptions on family with covariates			
Covariates	IRR	P value	95% CII)
Employment status	1.02	0.536	(0.94,1.11)
Type of organization: ref: Private			
Research agencies	1.01	0.764	(0.92,1.1)
Public agency	1.05	0.322	(0.95,1.16)
Higher education	0.946	0.226	(0.866,1.03)
Level of education: ref: undergraduate and below			
Postgraduate	0.985	0.702	(0.91,1.06)
Age category: Ref: 19-24 years			
25-35 years	0.914	0.148	(0.80,1.03)
36-45 years	0.837	0.01	(0.73,0.95)
46-65 years	0.85	0.037	(0.73,0.99)
Post estimation of age groups	P values		
25-35 vs 36-35 years	0.02		
25-35 vs 46-65 years	0.176		
36-45 vs 46-65 years	0.774		
Between all three age groups	0.037		

Table 11: Challenges and suggested solutions

Challenges while pursuing STEM careers	Potential solutions to the challenges
Limited scholarship opportunities and financial constraints to pay for basic needs compounded by lack of family support	Develop deliberate policy options that financially support women
Inadequate institutional capacity to support STEM courses such as resources – workloads like many students in university settings, equipment etc.	Enabling working environment
Lack of mentors (women pursing STEM)	Deliberate efforts to develop a pool of mentors and encourage them to mentor young girls
Gender discrimination at work place -transfers to other places, promotions based on gender, men get paid more than females, profiling female by marriage status and number of children	Policies to ensure gender balance – laws to support policy of representation – opportunity to support women who come back after maternity to fit back easily – flexibility to help women set up families early in life
Complex work schedule with long working hours that makes it hard to manage family and establish work-family balance coupled with unsupportive employers	Develop personal level strategies to balance work and family- e.g. flexible schedules and supportive leadership
Patriarchal perception of certain professions -male dominated professions	Develop strategies to create awareness on equity perspectives on STEM professions
Sexual harassment	Provide clear communication for sexual harassment and disciplinary structures to handle such cases -tactful diplomacy in handling sexual harassment cases -Self discipline

Cultural beliefs are further exacerbated by lack of exposure to some women that inhibit them from pursing STEM. In settings where men are expected to do everything, it makes it hard for women to excel even in basic education:

"Your husband will do everything for you, you don't have to go to school. They are discouraged from doing anything pertaining schooling and probably even working. That is why you find that, in some regions, you never find women who are educated. In some areas and in fact my area…most specialists are male doctors, not female. It is not because they can't do it, probably they got held back due to family or other factors. People go to med school, but they are not specialists, where are they? And the schools are there. But only the men mostly, succeed in such areas." IDI.

The doubt may also be enhanced by mentors or teachers who continue to drill the narrative that women may not make it in science. The conflicts between cultural demands and the statutory laws played a part in inhibiting women from completing school which locked them out of STEM. *"There is conflict between statutory law and cultural… the statutory law is saying something different from customary law, so it is very difficult especially in the rural settings to create awareness so that the girls are given equal chances. Because for example, the cultural law says that when a girl reaches form four and above is an adult, then the statutory laws says, a child who is below eighteen years is a child, so these two laws brings conflicts… there is a kind of conflict. This is the reason why most of the girls could not progress in school and most of the girls drop out of school."* IDI, Nigeria

Societal expectations and gender stereotypes

ii.   Patriarchal perception of STEM careers

A complex issue that seemed to operate covertly is the trust given to men and the perception that science is a man's field. Girls in some settings are discouraged from pursuing courses that are perceived to be for men. For example, ladies are told to pursue courses like teaching while men are told to pursue science courses due to the society's perception. *"So, the girl child is already disadvantaged.*

In some cultures, even in Nigeria, the girl child is already disadvantaged, some don't even get any education at all, so there must be that re-education. I think it starts with that. This area we are telling them that the girl child of course can also achieve in this area, we are to improve on the working environment such that a girl child can be an engineer in a place where she can be protected." IDI, Nigeria

Preferential treatment for men and sexual harassment

Another challenge was sexual harassment from male colleagues at workplaces or in school. This was expressed in different ways. At workplaces men are given preferential treatment compared to women. This is experienced in both school setting and workplace. Gender discrimination at work is perhaps due to the perception that certain jobs are for the male gender due to male's dominance in that field or the patriarchal perspective of the profession. In the workplace, reflections of how male counterparts are picked instead of females generated pressure for women to try and prove themselves that they were capable.

"Prove yourself. That is what I had to do. Like in presentation all of that, seminar, you have to do all of that to show that you are also worth the job assignment." IDI, Nigeria

The first form of discrimination is in the selection process where male are favored more compared to women:

"Some jobs when they ask for someone, they say they want a male person for the job. Because apparently a male person will look more serious or something or maybe command authority. The other thing, most of the time you find that...I have an experience when you are pregnant, the bosses are not happy, they wonder when you are giving birth and whether you are coming back to work." IDI. During selection process, there were reports of women being asked of their marital status which often denied them opportunities. *"For some specific things, do you have children? So, they can know what type of burden they are bringing to their company, not because they want to help you much. They just want to know whether to take you or not."* IDI. The third form of discrimination was based on pay where women reported getting at times a lower pay scale compared to men. *"And there are some [women] who get some little money, but of course the man will get it higher. For some reason they tend to get some favors and I don't know why. And at times you find you're doing the same job. Probably you're doing it better, but those are the few things that probably I have noticed, in my working."* IDI.

The other form of discrimination that was expressed was sexual harassment. There were cases where female candidates were asked for sexual favors to get jobs in the STEM industry as was expressed by one participant: *"And at times there is no evidence, you were not there*

So sexual harassment is still there and even in some jobs in the STEM industry.

to record the person, take a video of what they said… So sexual harassment is still there and even some jobs in the STEM industry. STEM industry has the interesting thing, you find there are jobs, but for a woman, for you to get a STEM job sometimes the person who is probably supposed to hire or maybe get you there, the place, as much as you are qualified will ask for a sexual favor… it depends on a person, but it is never worth it." IDI, Kenya

In other cases, male colleagues sought sexual favors outside office which led to women feeling uncomfortable to report to work. *"Honestly I would say I have also had to deal with the harassment that used to come, but then I have had male colleagues make some summary statements in the office or your boss trying to get you to see him outside the office and all of that…You have to be smart you don't just dare, your boss is sometimes your future is in their hands you have to be diplomatic about how you handle it. You don't just get to call them off, you have to find a diplomatic way of handling it or just may be joke about it a little and make them feel that, eventually when you see that you are not forthcoming, and you are good at your job, you would not have to suffer for that."* IDI, Nigeria

Often such cases are not reported due to fear of losing jobs. *"I have a colleague who was molested, assaulted, sexually abused outside work by a male colleague. But it was outside work and it was on a Friday evening. But we as her friends whom she told became a little bit scared thinking that there's this person in the compound at work who has got these tendencies."* IDI, Kenya. Other forms of sexual harassment were described in the context of not being taken seriously by male colleagues or when comments are made about the female dress code.

"So how safe is it for you to work late or to work on weekends when there is no one in the compound. There are such things or there are those days you dress in a certain way in the office and there is a way they would look at you and comment about you and not take you seriously even if I was a study lead. Or you sit down in a meeting and you are trying to chair a meeting and just give instructions and they would not take you seriously and they would sometimes make rather sexual comments." IDI, Kenya

The dilemma women face is the balance between being professional in the workplace and a dress code that will make them look serious and respected. *"And it was just difficult to be taken seriously…we are all made beautiful in God's image and as a woman sometimes you just want to look good, you want to wake up in the morning and dress good and put on some good make up and make your hair nicely, but you can't. You want to tone it down because you are always afraid that you won't be taken seriously at work."* IDI. In the school environment, women often reported being treated differently by their lecturers. *"Lecturers would treat the girls different from the boys and they would be extra hard on us. And you feel like that is just not the environment meant for you."* IDI.

There were also security concerns in the learning environment which harbored sexual harassment as reported by a female participant:

"I think part of the things that should be put in place for women…is security. Because you find now that some of these women get harassment from lecturers and their male counterparts and mainly it's unfair because just that you are one woman in a group of men, doesn't mean you should have to be harassed sexually for that. So, security measures also should be put in place for students, so they must feel secure, they should feel safe in their schools and learning environment, and they should be encouraged that besides their fear it doesn't mean they are less of human being or men are better. We are all equal." IDI, Nigeria

Family Level support

At family level, lack of family support may inhibit women from pursuing STEM especially if one experiences challenges that may require encouragement from close family members.

"My parents were not excited about it when I told them I wanted to study Biochemistry. So that is one of the challenges I had, and you know in the course of study as a student at some point you might have some challenges in your school. So anytime I had these problem they would just attribute it to… it is because you went for this course and all that and that didn't help me. And then as a young girl coming up, I mean family should be one of your basic support, when you are pursuing whatever it is in your life by being there as parents. And then in the school environment now where the ratio

of female to male in my class was more about men…all they see is they are all boys in the class, they just do whatever the boys are okay with. So, in cases where we needed to take a vote in the class for something, because we are outnumbered, they get their way a lot of the time." IDI, Nigeria

Suggested strategies to overcome challenges

i.   *Creating awareness on the importance of education for women*

Respondents observed that the way the African society is structed especially in the village makes it difficult for women to succeed in STEM. There was a systematic bias at the grassroot level where women are taught to be homemakers and engage in roles that limited their chance to get an education and eventually enrol in STEM. The need to empower communities, especially women at lower levels of the society was an important strategy in increasing the number of women in STEM.

ii.   *Creating awareness on STEM courses or subjects*

Another strategy of getting more women take up STEM courses and succeed was creating awareness early in life especially during secondary school education. This would involve conducting talks and STEM awareness sessions with the girls and explaining to them what it would take to pursue STEM courses and the benefits of being a STEM professional.

"They can begin awareness creation when they are in high school…say like talks, like education sessions or talks or awareness sessions. Girls can be told that they can choose a STEM course…they are told the importance of sciences and they are also told the importance of getting good grades. Because in Kenya for you to get into a STEM course, you must have good grades in the first place, so they should be told the importance of getting good grades in sciences." IDI, Kenya

iii.   *Mentorship and supportive leadership*

Mentorship programmes were also considered as an avenue to encourage more women to join the STEM field. Women already in STEM should be active in offering mentorship to those aspiring while those who are in leadership positions needed to use their positions to champion

inclusion of women in STEM and help those below them to grow. Perhaps, having leadership that can understand and generate opportunities to support female employees may help in addition to policies that can be sustainable.

"So, we need support and we have a male Vice Director at the university…he is very generous. I think he understands everything, and you know it's good, it's a very good thing for a Vice Director and he helps support females, you know teachers." IDI, Botswana

Such examples illustrate the need for flexibility on the part of employers to allow women manage work schedules in ways that cannot discourage them. In addition, there may be need for mechanism of engaging male counterparts on how best to support their spouses or female colleagues pursuing STEM related carriers. Ensuring that the workplace can support child care may also help women succeed in such careers.

iv.   *Self-motivation*

Self-belief was mentioned as one of the factors that was key in influencing women to take up STEM courses and succeed. Respondents pointed out that self-motivation was useful towards success especially in the STEM field which is dominated by men.

Small paying jobs and internships

While undertaking STEM studies, it was mentioned that one of the strategies that was employed to succeed was taking up jobs related to one's field of expertise to earn some money. This approach offered students an opportunity to gain experience while at the same time make some money to cater for their daily needs

.*"When I was in college, I was able to try to make money. Sometimes you know we even have cash crunches. So, with my little knowledge, not yet qualified, I could go and do some job and get paid. So that motivated me."* IDI, Kenya.

Table 8 summarizes some outstanding challenges and potential solutions as suggested by participants.

Policy options to support women in STEM

From the survey, women reported that policy options that encourages work related education and training (65%), providing women focussed grants (65%) and those that support work-life balance (60%) may help sustain women in STEM (Figure 5).

From the qualitative evidence, several issues were discussed. The policy issues are clustered in four main streams: role of parents and other women influencers at household level, role of school environment including higher education, and international agencies and employers.

a) Policy options that target the role of parents and the home environment

One of the approaches is to provide opportunities for parents to have enough information and social support that they require to assist their children in making decisions on STEM. Data suggested that the major role for parents in ensuring that girls and women are successful in STEM was provision of parental support to their daughters. This included supporting them both emotionally

through encouragement and motivation, and resource wise by providing finances required for completion of STEM studies.

A critical element at family and societal level to fight the patriarchal perception is the mentorship from women already in STEM and are considered successful. They can play a leading role in helping other aspiring women to join and succeed in STEM. Such women should actively participate in mentorship programmes where they can encourage other women to join the STEM field or motivate those already in the field going through challenges. Sharing of lived experiences on how successful women in STEM were able to navigate their way towards success were helpful. *"Mentorship if put in place…I believe more women would be motivated to pursue the sciences. I think from tender age, we start grooming our girl children to be passionate, we don't have to force them to do what we want them to do, we want to influence their interest in something they can do well. As parents, as family, as friends, encourage them and empower them with what they need to actually excel in this field and once they have that I believe they will be unstoppable."* IDI, Nigeria
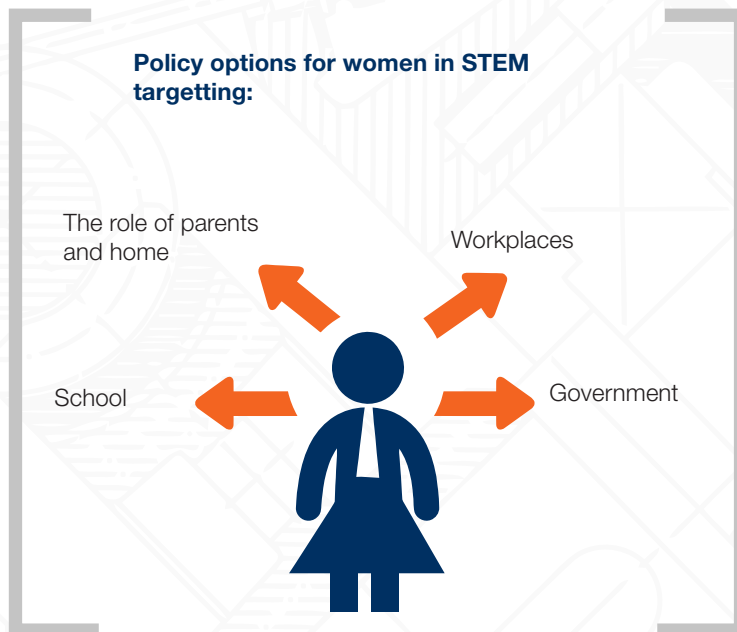

Policy options for women in STEM targetting:

The role of parents and home

Workplaces

School

Government

Figure 5: Suggested policy options to improve women participation in STEM

b) Policy options that target the school environment

Department support

Interviewees proposed support at lower levels at the university—at the departmental level. At this level, more course advisors needed to be deployed to provide support, encouragement and guidance to female students during their training.

Gender equity

There was emphasis on the need for fair representation of both gender with reference to the teaching staff. Currently, participants noted that STEM courses are mostly taught by male lecturers who sometimes may not relate to the challenges women go through while studying. There was also need for equal assignment of tasks regardless of the student's gender—this would ensure that women are treated as equals in accomplishing STEM related tasks. Giving equal opportunities for both women and men and encouraging women whenever they feel incapable was considered helpful in ensuring women are successful in STEM: *"Giving women more opportunities, giving them a platform to showcase whatever they can… make things more practical for them in campus. I feel that would help—just giving them equal opportunities. Because for my case I was given an unequal opportunity with the guys in school."* IDI, Kenya

Security and safe spaces

The security of women both at school and at the workplace was considered paramount in ensuring that they succeed in STEM. This entailed putting in place measures to provide safe spaces where women do not feel threatened or abused sexually by their male counterparts or teachers: *"Part of the things that should be put in place for women especially students is security. Because you find now that some of these women get harassed in the street, by lecturers and their male counterparts… It is unfair. Just because you are one woman in a group of many men, doesn't mean you should have to be harassed sexually for that. So, security measures should be put in place for students, so they feel secured. They should feel safe in their schools and learning environment "* IDI, Nigeria

Women scholarships

Interviewees highlighted the need for higher education institutions to award targeted scholarships for women. This is important especially for STEM courses that are expensive to finance: *"Need to create scholarship opportunities. In my case I have been very lucky somebody paid for me for my master's but for PhD, I have been trying to look for a PhD for a very long time and I have not gotten it. So, it is not just a matter of creating awareness but also opportunities in form of scholarships where women can pursue these STEM courses. They are very expensive if you have to do them out of pocket, so the universities can look for opportunities where women specifically can pursue STEM courses at master's and PhD level."* IDI, Kenya

Conducive learning environment

Lecturers' roles included ensuring that there was a conducive environment for learning for all students, especially women who may be underrepresented in STEM courses. Statements that implied gender biasness or made female students feel inferior to men, and outright favors towards men when opportunities for employment arose were considered harmful to women's progress in STEM.

Policy options that target international agencies

Extra Visa for caretakers

The role of international agencies majorly gravitated around making it comfortable for women to pursue their studies especially when opportunities arise that require them to separate from their families. Suggested initiatives to ameliorate women's challenges, especially those with children, was to plan for extra caregivers who would assist in raising children to accompany the mother abroad. *"International agencies should offer an extra VISA for a relative or somebody to help with the kids. It could be easier for women. Otherwise… a man could easily have a wife, have kids, leave them in Kenya and go to UK for years and his life continues."* IDI, Kenya

Gender equity

International agencies were also asked to consider gender equity when awarding grants, especially research grants. The current scenario

is gender biased in favor of men which means that less women are likely to grow and compete at higher levels of STEM excellence.

Seminars and conferences

Organizing for seminars and conferences targeting women was an avenue that respondents thought would benefit women in STEM. International agencies were therefore asked to consider organizing for workshops that would bring together successful women in STEM and other stakeholders to inspire other women in the STEM field or those aspiring to join the field.

c) Workplace policies

Appropriate remuneration

Proper remuneration of female employees working in STEM was considered a vital component that needed to be observed by employers for women to be successful in STEM. Equal pay, especially when women go for maternity leave was important for women. Proper renumeration for women would also facilitate payment of fees and settling other bills for women who may want to further their education. *"If they are paid well, if they are well represented, and if their institutions support them to be successful…and not to stand in their way to success…not making them feel like they will lose their job because of family responsibilities."* IDI, Nigeria

Enabling work environment

Implementation of policies that protect women from harassment at their workplace, provision of gender sensitive infrastructure such as toilets and focussing on professionalism rather than gender when awarding jobs were considered as aspects that contributed towards building an enabling environment for women to succeed.

Female recognition

Recognition of successful women in STEM was equally mentioned as a role that employers needed to observe to ensure women succeed in STEM. Women recognition on merit would encourage other women to work hard in their fields and become successful.

Gender equity

Ensuring that there is fair representation of women at all levels at work was emphasized by study participants as an important ingredient for success among women in STEM. Some of the suggested initiatives to ensure gender equity at work included: Putting in place measures to ensure that women are not left behind in relation to career development especially after maternity, instituting policies that protect women against discrimination and sexual harassment, being sensitive to the needs of women especially lactating mothers, and putting in place affirmative actions to ensure women are promoted and represented at higher levels of decision making.

"Women are given inferior positions because of their gender. The role of the employer is to make sure that promotions are based on the performance and merit. That will inspire women to go to school because they will know that the only way they will ascend is by working hard and getting better qualification… Also, it is the role of

> *"Women are given inferior positions because of their gender. The role of the employer is to make sure that promotions are based on the performance and merit. That will inspire women to go to school because they will know that the only way they will ascend is by working hard and getting better qualification… Also, it is the role of the employer to have better appraisal to encourage women to develop but not to frustrate them."* IDI, Zambia

the employer to have better appraisal to encourage women to develop but not to frustrate them." IDI, Zambia

Networking opportunities

Employers were encouraged to provide opportunities to women in STEM to interact with others working in the same field. Given that the STEM field is dynamic and changes in technology are rapid, it was important for women in STEM to network with others across the globe in order to better their knowledge and keep themselves updated with current professional trends and practices.

Offer more trainings

Closely related to networking opportunities was training and retraining of female staff. Of specific importance was the need to factor in women's needs and family responsibilities when designing these trainings. Online training and scheduling training when women can easily attend without jeopardizing their family responsibilities needed to be considered by employers.

"Creating opportunities for those women who have children. There are those women who cannot travel… it is not easy for them to travel and leave their children for training or work. So, you can try, for example if it is a training, you can try to do those trainings maybe over skype so that a woman can do it while she is still in the office. And putting those trainings…when the children are in school." IDI, Kenya

Women friendly policies

Implementation of policies that safeguard the rights of women at work was mentioned as key in ensuring that women succeed in STEM. Policies that are sensitive to the reproductive health needs of women, targeted support for women who want to pursue further studies, promotion of women at work and considering family needs when instituting transfers were recommended for employers' consideration.

"In the work place there should be provision of a place where a woman can actually have her baby in a nursery and while she is working. There is nothing wrong with having a nursery in a section of the work place…where there are girls taking care of them [so that] when a woman isn't busy she can just go down and see how her child is doing and then get back to work." IDI, Nigeria

d)   Government Policies

Education awareness

The government needed to advocate for education for girls and more so about the girl's equal ability as that of the boy child to succeed in STEM. Government's awareness creation of opportunities for girls to be supported in their pursuit of STEM courses was also encouraged *"It is a matter of creating awareness and education opportunities for women to pursue STEM… For the women in Kenya who are successful in STEM, they need to be recognized and used as role models to girls and other women."* IDI, Kenya

Education investment

Study participants were critical of the limited financial support the education sector receives from the exchequer. With limited financial support, the education sector will continue to struggle in providing quality education to all and more so, bridging the gender gap will be a mirage. African governments therefore need to increase the budgetary allocation to the education sector and take deliberate efforts to increase the number of women in STEM.

Policies that encourage gender equity

Institutionalization of policies that ensure fair representation of both gender in employment opportunities across various sectors including STEM need to be made a reality in Africa. Interviewees noted the trend of companies working in STEM preferring male employees to female and the need to put in place policies that will make gender equity a requirement by law when it comes to hiring.

Women friendly policies

Closely related to gender equity is the issue of implementing policies that are considered friendly to women working in STEM. This included instituting and implementing policies that support students with interest in STEM at lower levels of education and rolling out curriculums that attract women.

Inclusion of women in governance and policy making

Study participants noted the importance of government taking deliberate efforts in recruiting women in governance and decision-making positions. The rationale was that once women are in leadership positions; it will be possible

for them to advocate for the needs of other women especially in areas where they are underrepresented such as STEM. *"I think that we are just not getting enough of the women in science and in leadership positions in science. Women should be given an opportunity to air their opinion, so we just have 50-50 representation of women and men."* IDI, Kenya.

Women scholarships

African governments were also encouraged to consider providing opportunities for women to advance their studies and careers through provision of scholarships specifically for women. Participants noted the inability of women to pursue STEM courses not necessarily due to lack of ability but lack of resources and therefore governments should step in to assist.

Regional policy options to encourage women in STEM

Efforts to address gender inequalities and inequities in education and employment opportunities in Africa have been ongoing dating back to the 1940's when the United Nations established the Commission on the Status of Women with the sole responsibility of pushing for gender equality and advancement of women in the UN member states (38). Globally, concrete progress is being made in increasing the share of women studying scientific disciplines. Importantly, female participation at tertiary level is expanding beyond life and health sciences. Year after year, female scientists are being recognized at national, regional and global levels. Specific to the African continent, the African Union has initiated awards for women scientists. Five Nobel

Strategies for promoting gender equity in Africa

UNESCO STEM and Gender Advancement
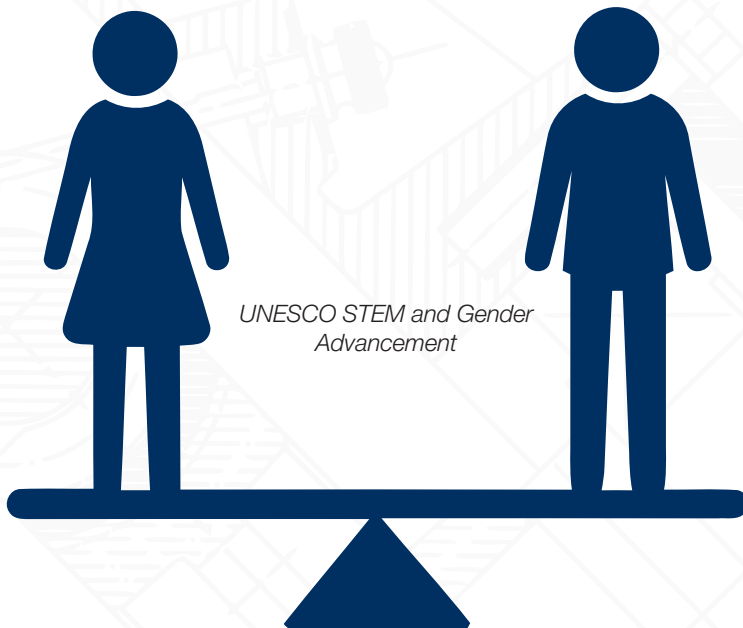
prizes have been awarded to women for work in medicine, physiology and chemistry (37). Through the poverty reduction strategies, education for all in primary and secondary education, many countries in Africa have narrowed the gender disparity in primary and secondary schools but gaps still exist at tertiary level. Moreover, the gender gap in STEM education and occupations in Africa remains a challenge (38).

A significant number of countries in Africa have developed policies to integrate women and gender issues more effectively into science. For example, in 2003, the Department of Science and Technology of South Africa convened an advisory body to advise it on priorities, key directions and successful strategies for increasing the participation of women in science. This agenda was aimed to address gender equality driven by a national 'gender machinery' consisting of a group of coordinated structures within and beyond government (37). Across African countries, several initiatives have been undertaken to attract girls and women in STEM, including continuous sensitization and lobbying of policymakers and legislators; promoting gender mainstreaming in policy and programmes; provision of incentives such as scholarships and award systems; special internships for female students; career guidance and mentoring in institutions of learning, adaptation of curricula, and interaction with teachers and parents (39).

Some of the notable strategies carried out for promoting gender parity in Africa include the UNESCO STEM and Gender Advancement (SAGA) which aims to contribute to improving the situation of women and reducing the gender gap in STEM fields in all countries at all levels of education and research. SAGA measures and assesses sex-disaggregated data, as well as supports the design and implementation of science, technology and innovation policy instruments that affect gender equality in STEM. SAGA aims to analyze how policies affect the gender balance in STEM, undertake inventories of STI gender equality policies, develop new and better indicators to provide tools for evidence-based policy-making, build capacity in Member States for data collection on gender in STEM, and prepare methodological documents to support the collection of statistics [33].

The second initiative is the African Development Bank's gender equality index which tracks and monitors women's representation on the

appointment of women to posts of responsibility. The index portrays the legal, social, and economic gaps between men and women. The index provides evidence on gender equality for 52 of Africa's 54 countries. It was designed not just to measure gender inequality, but to promote development and provide three important dimensions of gender equality: economic empowerment, human development, and laws and institutions. The index is action-oriented intended to help African decision-makers focus on and address barriers that prevent African women from engaging on a level playing field with men [34].

The third initiative is The Boardroom Africa (TBR Africa) which promotes exceptional female talent to boards across the continent. The initiative aims to break the barriers and help organizations realize the benefits of increased diversity on boards by accelerating the placement of female board directors. TBR Africa connects peer-endorsed, board-ready women with Chief executive officers and Board Executives across Africa for access to board and investment committee service. They maintain a database of talented women leaders and senior executives, making them easy to find, and trains, certifies, mentors, and prepares women for board membership. The Boardroom Africa also helps organizations realize the benefits of increased diversity by accelerating the placement of women directors, thus driving a shift in boardroom gender balance [35].

The fourth initiative is the Gender Summit Africa platform which brings together scientists, gender scholars and policy makers to jointly discuss available research evidence and agree where improvements are needed. Originally set up for the European science community, the Gender Summit has subsequently expanded to North America, Africa, and Asia Pacific and become a catalyst for development of communities of researchers, policy makers, and professionals from universities, research institutes, research funding organizations, research journals and science publishers, policy-making bodies, civil society, and industry [36]. Africa has hosted two Gender Summits: GS5 in South Africa and GS14 in Rwanda. The relationship between gender equality and research quality, and the need for action through scientific consensus, has been the main goal of the Gender Summit platform since its establishment in 2011. This

has enabled a multi-stakeholder dialogue on gender issues in science leading to an agreement on improvements that needed to be done.

Another initiative is the African Union Kwame Nkrumah Awards for Scientific Excellence Programme that honors two outstanding African women scientists from each of the five geographical regions of Africa. This programme promotes scientific development, encourages perseverance in research or academic careers, nurtures ambition, and raises the profile of science so that it contributes to Africa's development, poverty alleviation, and STI integration efforts [37]. Other efforts include mentorship programmes such as COACh-Cameroon and the Higher Institute for Growth in Health Research for Women (HIGHER Women) Consortium which have trained hundreds of women in career-building scientific skills, such as applying for grants, leadership, ethics, research quality, and project management [38].

Other ideas that have been suggested that can contribute to closing the gender equity gap in STEM in Africa include those that must balance their careers with family responsibilities. A strong family support system is therefore key to the success of many women [38] Perhaps a huge asset would be to educate partners and family to be more supportive and thus driving a structural and societal change by addressing the engagement and involvement of men in jointly carrying family responsibilities [38]. Lack of gender-friendly policy frameworks, such as the provision of child care facilities at the workplace or the lack of career re-entry programmes to encourage women scientists to resume their careers after taking a break to start a family, contribute to women scientists abandoning the science profession, ultimately widening the gender gap in STEM. This is reinforced by the failure to implement gender-sensitive promotion policies to ensure that women can advance in their careers. Not only do such approaches discourage many from pursuing long-term careers in science, but it results in women leaving the profession to pursue other endeavors. Individual factors also influence the decision of women to pursue careers in science. Lack of career support, such as mentors, networks and professional development opportunities, along with societal expectations, such as raising a family over pursuing a career,

dissuades many from seeking a future in science

Gaps in gender mainstreaming in STEM in Africa

Despite progress in narrowing the gender gap in STEM in Africa, the scarcity of women in STEM careers remains stark. This raises important questions on what drives these gender disparities in STEM? and what are the solutions? Research, mostly conducted in developed countries, points to distinct obstacles that confront women during three developmental periods (21). First, during childhood and adolescence, masculine stereotypes about STEM, parents' expectations of daughters, peer norms, and lack of fit with personal goals make girls move away from STEM fields. Second, during emerging adulthood, women feeling like misfits in STEM classes, women being vastly outnumbered by male peers, and lacking female role models make women avoid STEM majors or leave prematurely. Third, in early to mid-adulthood, subtle gender bias in hiring and promotion, biased evaluation of scientific work, non-inclusive department climate, juggling work– family responsibilities, and difficulty returning after a family-related pause, undermine the retention of women in STEM.

In Africa, the history of women marginalization and discrimination in education has persisted both in pre and post-independence times. In many African countries, especially those in the South of the Sahara, fewer places were available for girls and women in schools and universities in the early years. Even though the situation has improved and currently as many women as men can be admitted in a school/ university, marginalization and discrimination against women continues to influence the gendered nature of education and employment opportunities for women (38).

Despite the enabling policy environment and many initiatives that are being implemented to promote women's education in STEM disciplines in Africa, social-cultural and institutional barriers continue to prevent girls and young women from attending schools and universities and from performing equally to their male counterparts (38). Evidence shows that women's success rates in academic and senior positions are as good as men's, yet women tend to apply in smaller numbers, and they take longer to be promoted than their male counterparts. Efforts to increase

the numbers of female staff is a positive step but there is need to address the slower career mobility for women in higher education (38).

The STEM enterprise has long been dominated by men and therefore male perspective in policy development, performance evaluation, and interpersonal interactions are likely to favor men at the expense of women. Childcare and family responsibilities that are unequally shouldered by women account for some of this differential leading to a cumulative disadvantage for female employees in STEM (38). The working environment is not conducive for the reproductive years of the female in STEM. Policies that protect pregnant women and nursing mothers working in certain conditions that can be health hazards are needed (38).

One of the major obstacles to achieving gender equality in STEM in the developing world includes lack of data that can be used to provide guidance for programming and policy formulation. Unless these data are collected, properly analyzed and disseminated, gender responsive policies, plans and actions are at stake. Developing evidence-based interventions and policies is a difficult process in developing nations. In Africa, data reporting is not a common practice. In instances where data is available, quite often it does not

conform to international standards. There is need for investments in the collection of internationally comparable sex-disaggregated data and the use of a variety of indicators to capture the complex economic, societal and cultural environments across regions and countries (40). Important to note is the fact that all African governments met in 2005 and identified key gender issues in STEM and came up with action plans presented in box 1. (39).

This clearly shows that despite several positive initiatives undertaken through legal enactments, policies and programmes in Africa, the level of women's participation in STEM has lagged behind. This situation has been attributed to a myriad of factors including: lack of clear policy guidelines on how to improve women's involvement in STEM, lack of gender analysis expertise, women's reproductive roles, unequal workload sharing between women and men, educational imbalances and unequal representation in decision-making positions, lack of role models, masculine stereotypes in STEM, lack of data on gender, socio-cultural barriers, lack of equity on access to basic technologies, gender-insensitive curriculums and gender discrimination (39).

Box 1: gender issues affecting STEM in Africa

- Lack of gender disaggregated data in STEM at national and sub-regional levels to help policy makers, programme implementers make informed decisions on resolving gender disparities in STEM

- Limited participation of gender-oriented stakeholders to articulate gender issues in STEM review and formulation processes; hence most policies developed are not gender responsive;

- The gender mainstreaming of STEM policy formulation and review processes have not been enough to reflect the level of gender awareness that has been created and attitude changes made. Thus, there are very few engendered programmes;

- The education system in Africa is generally pyramidal with relatively equal number of enrolment of girls and boys at the lower levels followed by a steady decrease in of girls' enrolment at higher levels of learning, especially in science and technical subjects;

- Lack of coordinated mechanism for effective dissemination, networking and sharing of experiences in gender issues in STEM.

Box 2: Approaches to promote gender equity in work place

- Addressing unconscious bias in hiring and performance assessment;

- Implementing sexual harassment training and policies and ensuring redress for victims of harassment;

- Addressing the institutional culture and processes that penalize a woman's family life: performance evaluation in relation to hiring, tenure and promotion needs to accept flexible publication and research schedules to ensure that women (and men) who interrupt their career during their child-bearing years will not jeopardize their future career;

- Institutional gender policies need to be supported at the highest levels of governance;

- Decision-making and selection processes should be open, transparent and accountable. All professional, grant, selection and hiring committees should reflect a balance between male and female members;

- Modernizing human resources management and the work environment;

- Eliminating the gender pay gap, including the gender research funding gap;

- Making resources available to parents for retraining or re-entering the labour force; and

- Ensuring that women and men can take advantage of travel, conference and funding opportunities equally.
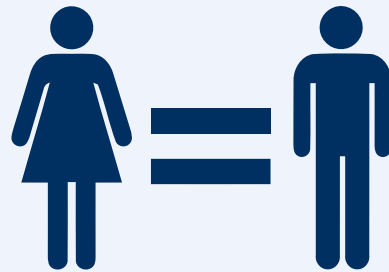
Organizational initiatives to reduce the gender gap in STEM in Africa

According to the African Union Development Agency (AUDA-NEPAD) formely New Partnership for Africa's Development (NEPAD), STEM education in Africa is confronted by challenges of participation, equity, exclusion, quality and relevance, resources and expertise. NEPAD and sub-regional groupings have created policies, plans and even units that are dealing with development of systems and networks that will deliver affordable, quality, equitable and relevant STEM education. Consequently, many African States have developed national policies on STEM education. Common issues in these policies include demystifying science and technology, encouraging the enhancement of targeted funding to the sector, promoting female enrolment in STEM education, building science and technology institutional and human capacity, protecting and promoting indigenous knowledge systems (38). Systematic collection of gender-disaggregated data is needed to support policy implementation and research. Both the European Union (EU) and Unite States of America (USA) systematically

collect gender-disaggregated data which is key in gender mainstreaming. For example, in the US, the National Science Foundation is required to prepare and submit reports to the US Congress on policy and programming to promote minority participation in STEM and to eliminate discrimination in STEM by sex, race or ethnic grouping. In Europe, since 2005, Eurostat has been given a mandate to collect gender disaggregated data by qualification, sector, field of science, age, citizenship, economic activity and employment in the business enterprise sector. South Africa and Brazil also collect comprehensive gender-disaggregated data. This needs to be emulated (37). Extensive research has been undertaken in Europe and the US to identify models which ensure that countries can benefit from the talent, creativity and accomplishments of both sexes when it comes to STEM. A number of approaches have been recommended to promote an equitable and diverse workplace that African countries can learn from and wisely adapt (37). They are presented in Box 2. A summary of several Africa wide initiatives that were identified from the scoping review are provided in Annex 1A. Three main observations

can be made from this synthesis: Firstly, the efforts identified largely focus on initiatives that are aimed at awarding or supporting women already in higher levels of STEM career. This means that the lower level initiatives are scanty. Secondly the initiatives appear to be led by international agencies who may have a bird's eye view of issues with limited connection with grassroot level efforts. Finally, the current Africa wide efforts may need to link with county level process and policies to ensure active translation to the action at regional level. This will add flavor to the needs of the younger women who may have interest to pursue STEM.

Grassroot efforts to improve women representation in STEM

Table 12 provides some of the grassroot options that have been cited in the literature. The literature suggests that when deliberate efforts to narrow the gender gap in STEM are implemented early, it may create opportunities for young girls to develop interest for STEM. Early exposure also provides opportunities for girls to begin linking day to day learning with the role of science, which will eventually create self-confidence. Efforts to have data for action will help building advocacy for encouraging women in STEM.

Table 12: Suggested grassroot based efforts to support women in STEM

Evidence based Suggestions for actions	Mechanism of Encouraging STEM uptake among women
Women in Early stages	
Linking schools with science museums , tertiary institutions, Science Fairs and Quizzes, Information Campaigns on science occupations and televised Competition	Links abstract learning to practical aspects of science and improving collaborations with students early in life
Career Days Clinics and Academic Support	
Create Informal STEM Learning Environments, After-School Activities	Encouraging students to have exposure to science opportunities through "doing"
Improving Data Quality and Accessibility	Enables tracking the problem -the lack of relevant data means that statistics are not available to document and track the problem, thus perpetuating the issue's lack of visibility
Incorporating Gender Equity into Teacher Education	Empowers teachers so that they can in turn empower their students to challenge prevailing views about teaching as a last option
Supporting Girls' Learning and Interest in Science Classrooms	Adapting classroom science to make it more engaging and interactive, encouraging relational and collaborative learning, and presenting science in a way that emphasizes social and societal connections
Awards and Scholarships	That support advancement of science
Women in Emerging adulthood	
Promote Opportunities for Peer Networking internships and mentorship programs	Foster a sense of belonging among women in STEM, and encourage female students to attend diversity conferences and professional society meetings which invest in students' success.

Evidence based Suggestions for actions	Mechanism of Encouraging STEM uptake among women
Provide Role Models and Mentorship for Women- helping women in science school and school re-admission policy	Academic departments should recruit senior women in STEM fields to present their technical work as part of department colloquia, brown-bags, and other special events, providing opportunities for these speakers to meet and mentor students.
Women in professional life	
Conduct Blind Review of Applications and Other Work Products	Committees should strive to mask each applicant's identity (gender, race). De-identifying applicants has been hugely successful and increased gender diversity in other fields, such as professional orchestras.
Foster an Inclusive Climate in STEM Departments	Fostering an inclusive environment can encourage research or teaching collaborations between junior and senior faculty, increase professional and personal interactions, and reduce professional isolation experienced by new faculty.
Support Work–Life Balance for STEM Faculty	These include stopping faculty tenure clocks for a year to accommodate childbirth, adoption, eldercare, and other caregiving responsibilities. Another policy offers 6 to 12 months paid leave for family emergencies. If these policies are instituted, universities should ensure that personnel committees not penalize faculty for reduced productivity during the leave period.
Professional Development	Professional societies and universities could provide structured professional development opportunities, so women can anticipate some of these barriers, plan how to navigate them, and predict important decision points. In some fields, career mentoring workshops provide support at professional society meetings. These workshops occur during major technical conferences making attendance easier because they piggy-back on key professional meetings.
Help Women Transition Back Into STEM Research Careers After a Break	Professional societies and universities could provide structured professional development opportunities, so women can anticipate some of these barriers, plan how to navigate them, and predict important decision points. practices, such as reduced fees for society membership and conference registration, would allow women seeking reentry to attend conferences and re-engage in their field, as a way of mitigating isolation, getting up-to-speed on new research, and making concrete plans to return to an academic career.

Chapter Four:
Discussion and Reflections

This study set out to investigate factors contributing to or inhibiting women's careers in STEM in Africa. The first objective of the study was to identify facilitating and inhibiting factors for Women in STEM in Africa. Study findings showed that women's success in STEM was influenced by various factors that reinforce each other at individual, family, societal and the work environment. At the individual level, personal capabilities and academic preparation contributed significantly towards the choice women made to pursue STEM related careers. The influence from other women working in STEM was also a significant factor in influencing women to pursue STEM related courses. Girls who grew up in families where women were professionals in STEM were motivated to take up STEM courses as women close to them acted as role models whom they looked up to. Other successful women in STEM outside their family circles also acted as role models for younger aspiring females who wanted to pursue STEM courses or advance their education.

At family level, there appears to be support for ladies to pursue STEM related careers. Quantitative findings showed that 78% of women in STEM reported support from family while only 2.4 percent were highly negative, and 7 percent were not supportive. The inference here is that the problem of women pursuing STEM at individual level is unlikely to be personal capabilities or support from family members. At societal level, the role of attitudes, values, beliefs and the working environment play a vital role in influencing women to pursue STEM. Significantly, over two thirds of all respondents agreed that patriarchal attitudes contribute to influencing women pursing STEM related careers. Issues of discrimination against women in accessing decision making positions, hegemonic masculinity perpetuated by socio-cultural values and beliefs and organizational gender inequality perceptions among both males and females affect the ability of women to succeed in STEM. Research by Steele

and Aronson [14] has shown that attitudes manifest as stereotypes that negatively influence performance by shifting an individual's focus from performing a task to worrying that low performance will confirm a negative stereotype about a group to which the individual belongs. Research has shown that hegemonic masculinity and organizational gender inequality perceptions contributes to gaps in academic performance between races [14-16] and between women and men [15-17]. In this case, negative stereotypes about the ability of girls to excel in STEM can substantially lower their performance and their aspirations to become competent scientists in future [10, 18] yet men continue to outnumber women, especially at the upper levels of these professions. In elementary, middle, and high school, girls and boys take math and science courses in roughly equal numbers, and about as many girls as boys leave high school prepared to pursue science and engineering majors in college. Yet fewer women than men pursue these majors. Among first-year college students, women are much less likely than men to say that they intend to major in science, technology, engineering, or math (STEM.

Regarding the work environment, nearly 80 percent reported that women deal with obstacles that men don't and that 63 percent constantly need to prove themselves of their capability as men. Findings on experiences of women in the work place that might limit or facilitate women in advancing in STEM showed that recruitment, promotion and gender relations play a great role. Even though most women (90%) agreed that they were recruited on merit, only about 57 percent reported that they are sufficiently rewarded based on their academic and professional qualification. Women also seem to agree that men in STEM have more career opportunities than women which speaks to the potential challenges of men being favoured in work places. This narrative is even made clearer by the fact that a few organisations

have attempted to attain gender parity with majority of respondents agreeing that there are no gender mainstreaming initiatives being implemented at their workplaces. Studies have associated gender discrepancies in STEM with biasness and discrimination against women [10]. It is evident that people hold negative opinions of women in "masculine positions" such as scientists or engineers which implies that they are likely to judge women to be less competent than men unless women are exceptionally successful in their work [10]. A randomized double-blind study showed that science faculty members were biased towards the male gender as significantly more competent and hirable than the female candidate and yet both genders had equal capability and competence [25].

Generally, this study has documented key factors that either facilitated or inhibited women in STEM. The main factors that facilitated women to succeed in STEM included: availability of equipment and resources where study participants attributed their success in

STEM to availability of resources when they were undertaking their respective courses; aspects of empowerment of girls either through financial support or ensuring that female students were equally treated as their male counterparts, affirmative initiatives such as payment of school fees for girls, and being offered advice and direction regarding STEM-related career path; support from members both in the nuclear and extended families who were either working in STEM related fields or family members who provided material support or encouragement to women; peer support from student of the same or different gender—support from male students seemed to be key in ensuring that female students completed their STEM courses; availability of scholarship opportunities for women; support from teachers especially those teaching mathematics at lower levels of education, and supportive lecturers at higher levels of education. Factors that inhibited women in STEM included: demanding schedules for STEM related careers that made it hard to either start or maintain the family;
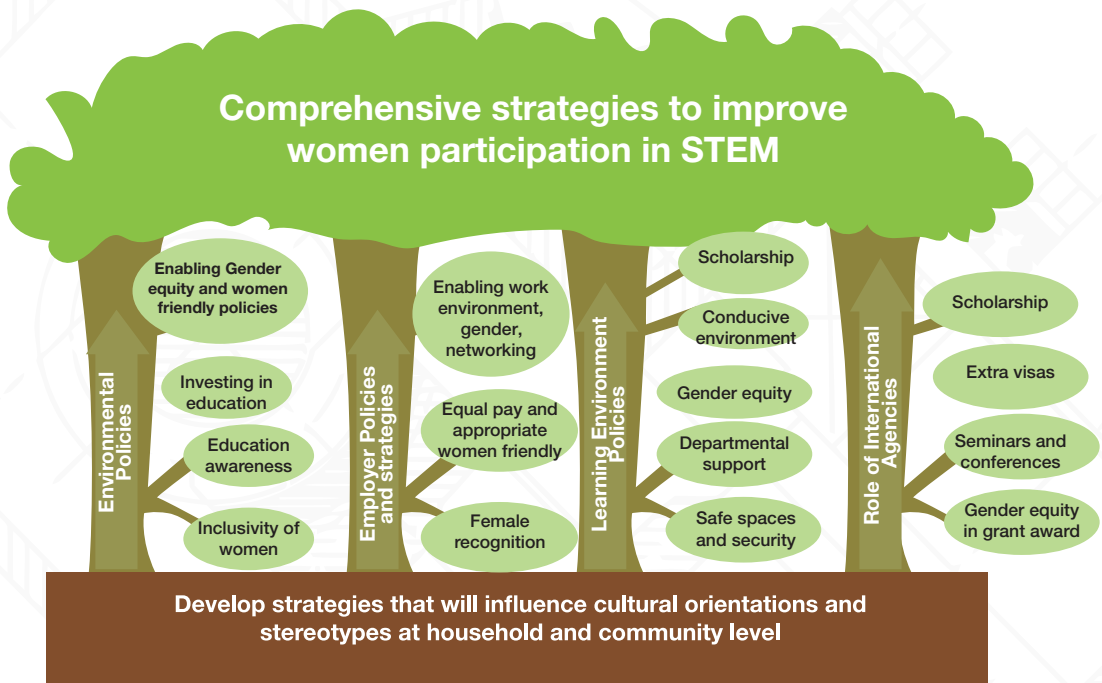
Infographic adaptation: Ecomedia

Figure 5: Possible policy options that can support women in STEM

unsupportive work environment where female employees had challenges getting time off work to attend to family matters; self-doubt and societal expectations; patriarchal perception of STEM careers with the perception that science is a man's field; preferential treatment for men; and sexual harassment. The conceptual framework that guided this study envisages the critical role of self-efficacy in educational attainment in STEM [39-43]. Studies have shown that beliefs about personal capabilities, students' expectations and interest in STEM-related activities, and earlier plans to major in STEM play a significant role in achieving success in STEM [41. Apart from individual factors, research has shown that for women, the role of other individuals' encouragement in promoting their perceptions of their capacity for a math-related career was important for their success [43]. Women's self-efficacy for math-related careers is likely to be shaped by positive perceptions by family members, teachers, and peers which can enable women to continue in math-related careers despite academic, financial, and other barriers [43].

The second objective was to explore illustrative examples or cases of local, national, regional, continental and international initiatives/programmes that either directly or indirectly improve women in STEM careers and fields with emphasis on Africa. Findings from this study are summarized in Figure 5. As the illustration shows, efforts should begin from addressing the root causes of perception by developing strategies that will influence cultural orientations and stereotypes at household and community level. Interventions to ensure comprehensive support structures for women in STEM need to be anchored in law through relevant policies.

Limitations

Findings from this study need to be interpreted with caution on the following grounds:

- The sample size for the quantitative survey was limited. In three months, the study team made several efforts to reach out to women in STEM and encourage them to take up the online survey but the response rate was low. We have therefore presented quantitative findings using descriptive statistics and triangulated our methodology by marrying quantitative findings with qualitative findings.

- The respondents in this study were not equally distributed across Africa. The study team made efforts to recruit participants across the continent but the response rate varied across regions. For example, more women in STEM in East and West Africa agreed to participate in the interviews compared to other regions.

Conclusion

The study has demonstrated that women's success in STEM is influenced by various factors that reinforce each other at individual, family, societal and the work environment. At the individual level, personal capabilities and academic preparation influence the choice of whether women pursue STEM related careers or not. The choice to pursue STEM related careers was further influenced by other women working in STEM who acted as role models. Factors at societal level also played a significant role in influencing choice and success for women pursuing STEM related careers. To this end, patriarchal attitudes at a macro level affected the choice of women to pursue and succeed in STEM. The success of women already in STEM was highly influenced by the work environment.

The recruitment process, promotion and gender relations played a great role in women's success in STEM. Policies to address the gender gap in STEM exist but they are rarely implemented.

There is need for a multipronged approach that addresses challenges that women face in their quest to pursue STEM courses and succeed while in practice. Approaches should pay attention to factors that affect women's success in STEM at the individual, family and societal levels, and the work environment. Policy and programmatic measures should be institutionalised to safeguard gender equity in STEM both in the education system and work places.

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Annex: Selected African initiatives that support STEM

Initiatives	Key focus areas	Implications for future efforts
Organization for Women in Science for the Developing World (OWSD)	Provides research training and networking opportunities for women scientists in the developing world at different stages in their careers. -The first international forum to unite eminent women scientists from the developing and developed worlds with the objective of strengthening their role in the development process and promoting their representation in scientific and technological leadership.	Scientists but not lower level as women begin their careers. -Will advance already established scientists
The AfDB's Gender Equality Index	Index that provides evidence on gender equality for 52 of Africa's 54 countries. It was designed not just to measure gender inequality, but to promote development.	Also focus already established scientists to advance them in STEM -Efforts relevant for tracking inclusivity of women in science and is relevant for measurement of progress
L'Oréal-UNESCO For Women in Science International Awards	Identify and support eminent women in science throughout the world. Each year, five Awards Laureates are recognized for their contributions to the advancement of science, in Life Sciences or Physical Sciences in alternating years.	Focus on already women in science and can be used to continue Highlighting successful cases as role model for younger women in STEM
Merck STEM Initiative	The "Merck STEM Program for Women and Youth" aims to empower women and youth in the fields of STEM. Through its annual platform, the UNESCO-Merck Africa Research Summit (MARS), the Merck STEM program prepares the road for young and female African researchers to drive Africa's development as an international hub for research. In addition, the Merck Foundation targets to empower girls and women researchers across Africa through various initiatives, including providing training opportunities, setting up computer libraries in schools, and appointing the UNESCO-MARS research award winners as ambassadors for the Merck STEM Program	The initiative focus on younger level women in science will enhance the role of women in STEM early on. However, the initiative is small scale. -efforts to sustainably ensure an African wide initiative will be key at lower level
UNESCO Merck Africa Research Summit (UNESCO MARS Summit):	The Summit, recalling UNESCO's priorities which are Africa and Gender, aims to build research capacity and empower young African researchers with special focus on empowering women in the fields of research and healthcare to raise the level of scientific research. Moreover, it can be considered as the fertile ground to improve North-South and South-South cooperation among STEM investigators.	The initiative focus is on higher level and appears to network women in the south and north

Initiatives	Key focus areas	Implications for future efforts
African Union Kwame Nkrumah Awards	Set up in 2008 the award are in memory of the Great Pan-Africanist and First President of the Republic of Ghana, Dr. Kwame Nkrumah, a firm believer in African liberation and unity. The programme is implemented at national level for young researchers, regional level for women scientists and continental level open to all scientists. The Continental level is the highest level of the programme. The objective is to give out scientific awards to top African scientists for their scientific achievements and valuable discoveries and findings.	Efforts cover higher level scientific excellence
African Women in Mathematics Association (AWMA),	Aim is to promote women in mathematics in Africa and promote mathematics among young girls and women in Africa. It encourages African women to take up and continue their studies in mathematics and to promote mathematics among women. Founded in 2013 with twenty-five members, AWMA has more than three hundred supporters and coordinators in all five regions of Africa. Every other year, AWMA holds a general meeting. A newsletter will be published at least once a year, AWMA has a website and an e-mail network as well.	Although it has a regional presence the focus is narrow in mathematics which may a be a good starting point to advance science among young women
International Day of Women and Girls in Science	On 22 December 2015, the UN General Assembly adopted a resolution to establish an annual International Day to recognize the critical role women and girls play in science and technology communities. In welcoming the efforts of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the United Nations Entity for Gender Equality and the Empowerment of Women (UN-Women), the International Telecommunication Union (ITU) and other relevant organizations that support and promote the access of women and girls and their participation in science, technology, engineering and mathematics education, training and research activities at all levels. 11 February of each year is the International Day of Women and Girls in Science.	The UN-led initiative is a critical driver to enhance women in STEM but it needs to be backed by grassroot level initiatives that pushes women up in STEM
UNESCO Prize for Girls' and Women's Education	UNESCO Prize for Girls' and Women's Education honors outstanding and innovative contributions made by individuals, institutions and organizations to advance girls' and women's education. It is the first UNESCO Prize of this nature and is unique in showcasing successful projects that improve and promote the educational prospects of girls and women and in turn, the quality of their lives. Funded by the Government of the People's Republic of China, the Prize is conferred annually to two laureates and consists of an award of USD 50,000 each to help further their work in the area of girls' and women's education. The Director-General of UNESCO awarded the Prize for the first time in 2016.	Like many higher-level efforts, this approach focus on advancing those already in STEM