AFRICAN WOMEN IN STEM: **PARADIGMS AND LIMITATIONS**

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EXECUTIVE SUMMARY

The study investigated and evaluated the proximate determinants that influence the participation of women in Science in Africa. The study sought to provide answers to the following identified research questions:

i) What factors influence the absence of and constraints facing African women's participation in Science
ii) Are there visible impact and benefits for increasing the number of women participating in Science careers in Africa?
iii) Are instructional tools for science delivery in institutions in Africa fit for purpose?
iv) What do equity goals for women in science amount to in a context of mass unemployment, underemployment, deficit funding and lack of probity in funding for Science?
v) How important is equity in science, when there exist other underlying inequalities such as ethnicity, tribalism, race, area of residence, accessibility, affordability and erroneous views that treat men and women as homogenous, thereby failing to tackle the strategic gender needs of women in Science?

A non-probability sampling technique was used in this research. The non-probability sampling has not been utilised to generalise to a wider population but rather to generate some potential and valuable insights. The sample included theoretical sampling of existing theoretical insights done in previous studies and to evaluate emerging insights from these studies and their applicability. In addition, a convenience sampling of 135 people, 89 females and 46 males, from the Southern, Western and Eastern geographical regions in Africa, was utilised to obtain answers to the overarching research questions. The instrument used to interview the population combined quantitative and qualitative methodology. This was done purposefully to overcome the drawbacks involved using either method exclusively. A bivariate analysis was performed using the Pearson Chi-square in order to establish a statistical association between the various measures of equity in STEM and gender of the participants. A T-Test was also conducted to examine the gender difference in the STEM fields which is an equity issue. The results of our analyses were interpreted appropriately.

Despite overall achievements, women are still under-represented in leadership positions in the STEM fields due to their susceptibility to constraints facing women in STEM fields. Findings showed that the major factors that may influence the participation of women in STEM fields are: Firstly, the perception that STEM is a technical/difficult/stressful (26.7%) terrain. Secondly, the society also believes that it is a field designed for males (20.7%). Another major factor that may influence the participation of women in STEM fields is the African society and culture (15.9%). Aside fear (8.9%), choice (2.2%), non-interest (2.2%), other factors (8.10%) may also influence the participation of women in the STEM fields.

Findings also revealed that lots of funding and opportunities (85.9%) exist for women in science. This indicates a recognition that equity in STEM is an unexploited opportunity for growth/development in a constantly evolving society. In view of the focus shifting to funding for women in STEM, there were cautionary remarks that excluding men may be hurting the cause and thereby counterproductive. Disempowered men may intuitively impose the glass ceiling on women in a largely patriarchal society in a manner that could actively interfere with the success of women.

On the fitness for purpose of tools used for instructions in institutions, some participants stated that instructional tools were adequate, and others stated that tools were inadequate. The test for significant difference among the results for different levels of education was carried out using a one sample t-test at test value = 4.0. The t-test result indicated that the mean difference (0.43457) is significant at $t = 2.795$, $p < 0.05$. The conclusion therefore could be that the instructional tools are fit for purpose. Nonetheless, the instructional methods used in teaching are on the average. A test for significant difference was carried out using one-sample t-test at test value = 3.0. The t-test result indicated that the mean difference (-0.06173) is not significant at $t = -1.025$, $p > 0.05$. It can therefore be concluded that the instructional methods in Africa are not fit for purpose.

The bivariate analysis utilised indicates no significant differences in reported equity between men and women on the two measures of equity. Pearson- chi square was used to assess the level of association between sex and some measures of equity. A relationship was said to be significant if the derived p value is less than 0.05. As Table 4 indicated, most of the participants (37.4%) were slightly satisfied with the quality of support received when studying STEM. However, there was no significant relationship between the quality of support received when studying STEM and gender, $p= 0.112 > 0.05$. Moreover, 58.5% of the participants did not experience discrimination during their academic or professional pursuit. Similarly, there was no significant relationship between level of discrimination and gender, $p= 0.256 > 0.05$.

With a history of racism in South Africa, equity in science becomes difficult to manage as everything is interpreted through the lens of racism rather than competency. Competency is sometimes tilted in favour of those who had the resources and income to have a proper educational background. Intergenerational inequality affects equality of opportunities. Inequality in other areas may have a cumulative disadvantage for equity in science because many of these areas of inequalities are connected and focussing on one area i.e. science alone, may undermine other issues affecting inequalities in society. This however does not mean that equity in science ought not to be addressed. Science brings innovation.

The critical contextual factors, affecting women's uptake of STEM have been identified, through a qualitative and quantitative survey of multiple stakeholders in parts of Africa. It is hoped that further research would develop and extend the theoretical insights that have been provided. Further research might want to capture the experiences and perspectives of students studying STEM. It would be helpful to further explore countries in North Africa where women researchers are above the 30th percentile and the current graduate rates of students in STEM and possible employability track studies of STEM graduates.

1.0 THE CONCEPTUAL FRAMEWORK FOR THE PROXIMATE DETERMINANTS OF UNDER-REPRESENTATION OF WOMEN IN SCIENCE.

All over the world, there has been a growing awareness and policy driven initiatives on the importance of women in science and the rationale for investing in women as a basis for efficiency and parity. The conceptual model for this study posits that motivation, pedagogy, structural and extraneous socio-economic factors influence the number of women who undertake a career in Science. How these determinants interact with each other and other mediating factors will be explored. This study, which combines quantitative and qualitative research methodologies, will utilise a rigorous approach in testing existing theories of underrepresentation of females in STEM careers in Africa and provide a revision of theory based on evidence. In this study, high quality research evidence will be prioritised over outdated anecdotal evidence that are often oversimplified. Research based on speculation and experience is antithetical to bridging gaps in the science career. Evidence extracted from questionnaires and interviews would be critically appraised. A rigorously evaluated research of this nature would distinguish between what is evidence-based and how it overlaps with consensus-based. Results of this study would be improved and understood by discussing results with a focus group. The potential causes of women's under-representation would be well-defined and would stipulate whatever is anticipated to be significant in finding solutions.

1.1 RESEARCH QUESTIONS

Potential questions which evolve from literature review will be assessed and applied in the survey to determine their adaptability in the African setting. However, for the purposes of this research, there are five broad overarching research questions underpinning the conceptual framework:

1.1.1 What factors influence the absence and constraints facing African women's participation in Science?
1.1.2 Are there visible impact and benefits for increasing the number of women participating in Science careers in Africa?
1.1.3 Are instructional tools for science delivery in African institutions fit for purpose?
1.1.4 What does equity goals for women in science amount to in a context of mass unemployment, underemployment and deficit funding and lack of probity in funding for Science?
1.1.5. How important is equity in science, when there exist other underlying inequalities such as ethnicity, tribalism, race, area of residence, accessibility, affordability and erroneous views that treat men and women as homogenous thereby failing to tackle the strategic gender needs of women in Science?

1.2 THE CONTEXT

Africa is the second largest continent in the world. The continent comprises 54 countries, 9 territories and 2 de facto independent states. It has an estimated population of 1,310,953,971 representing 16.64% of the total world's population. Africa has a very low population density of 45 per square kilometre. The median age in Africa is 19.4years. According to the United Nations Department of Economic and Social Affairs and the World Bank (2018), the projection of sex (female to male) ratio of Africa is estimated to be between 100-105 in the Northern parts of Africa and 95-100 in the Southern parts. On the other hand, UNESCO Institute of Statistic in its fact sheet on Women in Science (2018) estimated that an average of 31.3% of African Women are researchers. It is arguable whether this headcount obtained from full time and part time women in Africa is truly representative of science researchers in Africa.

Nonetheless, judging by this statistical sample of data obtained from UNESCO, a wide disparity exists in the region. Africa, taken as a whole, in comparison to other regions of the world has the lowest number of female researchers. In the Chad region, only 4.8% women are researchers. In Nigeria, the most populous country, the percentage is 23% while Ethiopia has 13% and Ghana has 13.3%. Only one country in Africa, Tunisia (55.4%), had more than 50% female representation in the field of research, a Muslim majority country with more women in STEM than in the United States. The majority of countries in this study of 42 African countries have a dismal female researcher representation of lower than 30%. Nigeria's figure is significant because Nigeria is the most populous country in Africa and the 7th in the world with an estimated population of 199,804,069 million (World Population Review, 2019).

The sex ratio between male and female in Nigeria are fairly even until the age of 65, when women outnumber men. Therefore, if only 23% of UNESCO's headcount in Nigeria are female science researcher, it means that women account for less than a quarter of the total STEM workforce. This under-representation may be suggestive of the fact that women probably face some form of adversity in navigating a career path in STEM. Examining the situation in the 20 most populous countries against the data of UNESCO's estimates of women in science portrays a very disturbing low density of woman in science given the estimated population margins of equal ratio of men or to women.

Table 1: Percentage of women science researchers in 20 most populous African countries

Country's population by ranking	Population	Women Science researchers	Median age	Country's population by ranking	Population	Women Science researchers	Median age
1. Nigeria	199,804,069	23.3%	18	11. Morocco	36,635,156	33.8%	30
2. Ethiopia	110,135,635	13.3%	20	12. Angola	31,787,566	27.1%	17
3. Egypt	101,168,745	44.1%	25	13. Mozambique	31,408,823	28.9%	18
4. DR. Congo	86,727,573	10.3%	17	14. Ghana	30,096,970	18.3%	21
5. Tanzania	60,913,557	29.8%	18	15. Madagascar	26,969,642	33.2%	20
6. South Africa	58,065,097	45.0%	27	16. Cote d'Ivoire	25,531,083	16.5%	19
7. Kenya	52,214,719	25.7%	20	17. Cameroon	25,312,993	21.8%	19
8. Uganda	45,711,874	29.8%	16	18. Niger	23,176,691	No data	15
9. Algeria	42,679018	34.8%	29	19. Burkina Faso	20,321,560	15.2%	18
10. Sudan	42,514,094	40.0%	20	20. Malawi	19,718,743	19.5%	18
The table above has been designed using figures culled from UNESCO (2018), United Nations, Department of Economic and Social Affairs, Population Division (2017) and the Worldometers, African Countries by Population (2019)							

This table incorporates the percentages of women science researchers in the twenty most populous African countries. The percentages were obtained from a UNESCO study done in 2018. This table does not provide a trend in population count or median age in relationship to the percentage of population of women researchers. The reason is because UNESCO's studies on female researchers were for a fixed year, unlike a longitudinal research that would have permitted, not just analysis but investigations of trends over a prolonged period of time. Nonetheless, the reason for creating such a table is to study patterns among the most populous countries and correlations if any. Also contained in this table are the population ranking of the most populous countries in Africa and the median age derived from United Nations, Department of Economic and Social Affairs, Population Division (2017) and the Worldometers, African Countries by Population (2019) .

With South Africa having the highest percentage of women science researchers at 45.0% and the Democratic Republic of Congo having the lowest percentage of women science researchers at 10.3%, the figures portray that female researchers are less than fifty percent in each African country, and this emphasises the fact that science research is dominated by males in these countries. While a few countries in this table have women science researchers in the thirtieth percentile (Algeria – 34.8%, Morocco – 33.8% and Madagascar – 33.2%), and Egypt and Sudan follow closely behind South Africa with 44.1% and 40.0% respectively, most of the countries have a percentage of women science researchers below 30%. This is indicative of the gender inequality in science fields in African countries.

Take Nigeria for example, despite being the most populous African country with 199,804,069 people, only 23.3% of science researchers are female. Ethiopia, which is the second most populous African country with 110,135,635 people, has an even much lower percentage of science researchers represented by women at 13.3%. Democratic Republic of Congo, which has the lowest percentage of female researchers at 10.3%, has quite a large population of 86,727,573 people.

Interestingly, the median ages of the populations in these twenty African countries range from fifteen (15) years to thirty (30) years, indicating a young population. Uganda (population 45,711,874) for instance has quite a low median population age of sixteen (16) years and has only 29.8% representing female researchers. In addition, Angola (population 31,787,566) has a median population age of seventeen (17) years and only 27.1% representing female science researchers.

Young median ages indicate less experience, less knowledge and less developed work skills. If these African countries have low median population ages, it is likely to affect the numbers of women in research because the skills required to embark on such a career have not been attained. Indeed, at such young ages, many women are still discovering themselves. It would make sense that the younger the median age, the lower the percentages of women science researchers.

Looking at the countries with higher percentages of women researchers, South Africa (45.0%) and Egypt (44.1%), higher median ages of twenty-seven (27) years and twenty-five (25) years respectively are observed. Even Algeria (34.8%) and Morocco (33.8%) have fairly high median ages of twenty-nine (29) years and thirty (30) years respectively. This is in sharp contrast to countries like Democratic Republic of Congo, which has a median population age of seventeen (17) years and a representation of only 10.3% for women researchers, or Cote d'Ivoire, which has a median population age of nineteen (19) years and a female researcher representation of only 16.5%.

Although it may not be a definite pattern (Madagascar with a median population age of twenty (20) years has a decent percentage of women science researchers at 33.2%), it can be inferred that in countries with higher median population ages, women have taken the years, the time and the resources to develop and nurture the skills required to become researchers. UNESCO's figure for Egypt 44.1% is closely corroborated by the figures given by the Egyptian observatory for Science, Technology and Innovation which puts the figure of female researchers at 43%. This figure is one of the most impressive for Africa aside Tunisia's leading figure and that of South Africa.

It could be said that countries with an older median age should have more women science research, assuming that figures provided by UNESCO are a higher level or tertiary level indicator. Where the percentage is lower, compared to total population and the same indicator for men, this may indicate a decline in the participation of women in science at the researcher level.

Notwithstanding the relationship of median ages to the percentages of women in science research, there is clearly a lack of female researchers in African countries and more needs to be done, among both men and women, to raise awareness on the small numbers of women in the science and the need to encourage and support more women to embark on and remain in education and careers in this field.
UNESCO's statistics on Africa taken in a holistic way, indicates a grave under-representation of females, and consequent domination of males in the research industry in Africa (See Graph 2). This challenge occurs amidst an increasing need for more engineers and technicians to combat poverty, improve living standards of communities, contribute to advancements in health, food, security, sustainable energy, and to keep up with technological trends in the world. In Africa, women continue to trail behind their male counterparts both in STEM education and careers. Though some studies have explored the gender disparity both at the tertiary education level and employment levels, there is not enough published data documenting how extensive the inequality is and, consequently, the need for more females in this sector.

2.0 USEFUL BUT LIMITED TRACTION OF PREVIOUS STUDIES

In different parts of the world, a number of theoretical presuppositions have been offered on factors that affect the pursuit of studies in STEM and, more especially, the disproportionate access affecting women. In looking into causative factors, previous studies may have limited traction and conversely, solutions or insights offered would have little impact and sustainability. Little and speculative data exists in Africa on proximate determinants for the impediments affecting the requirement to increase women's access and representation in STEM. However, the suppositions from other continents may not necessarily be applicable to Africa but the data and information they provide could be used as a basis to uncover valuable insights into the African situation.

2.1 STUDY1

Harvard Business Review author, Joan Williams, in a research co-authored with two other scholars, Katherine Phillips and Erika Hall in 2016, dismissed pipeline issues and personal choices as reasons that bars most women from science. Pipeline issues are the theories that contend that failure to interest women in science subjects affects their choice of the discipline in the future while personal choices are theories that contend that women forego a career in science because they wish to attain a work-family life balance. They debunked these theories whilst upholding gender bias as the primary reason for low numbers of women in science in America. They arrived at this conclusion from a survey of 557 female scientists and 57 in-depth interviews of female scientists, identifying five patterns of bias;

- Women, unlike men in the same workplace, have to prove themselves over and over again regardless of their level of experience
- Women in the workplace constantly struggle between being regarded as incompetent when they are feminine and not likeable when they exhibit "masculine" traits like assertiveness, directness and competitiveness
- The ability to deliver and the competence of professional women are questioned in the workplace when they have children
- Women create a hostile or unwelcoming environment for other women instead of supporting each other because they have been discriminated against by men. This leads to competition and discord among these women.
- Minority tribe women restrict interactions with colleagues to office related functions and avoid social interactions to avoid being labelled as incompetent

These biases can drastically lessen the confidence of women in the workplace and limit their ability to perform. It also affects their enthusiasm about their careers and cascades down to young students who seek but do not find role models that will encourage them to undertake studies in science related programs.

2.2 Analysis of Study 1.

The survey that will be carried out in Africa will assess these identified patterns to detect and measure their applicability in Africa. Whilst these patterns of bias could be contextualised, it could be that they might also be heavily influenced by ideas current in wider circles of modern society where eradication of gender bias is seen as the silver bullet. One interesting factor noted by this report however is that women who had been discriminated against tend to create an unwelcoming environment for other women because of the discrimination they faced from men. While it would be expected that there would be camaraderie among these women, the situation presented here is one of competition and hostility. Then men get the blame for the antagonistic behaviour women face from other women.

The pipeline issues challenge posed by the dynamic process of educational teaching and learning and its relationship with motivation, social structures and mindsets cannot be undermined or easily dismissed? Could it be that the learning process and the outcomes of learnings are flawed and non-responsive to the needs of women? Does the socio-political and economic nexus, in which education is firmly lodged, not influence stereotypical thinking that endorses sexism and scholarly isolation of women in science?

2.3 Study 2

A study carried out by Hill, Corbett and St. Rose (2010) highlights various reasons why there are few women in science. The report looks at stereotypes, biases and departmental culture among other things. According to the report, two stereotypes are prevalent in society. The first stereotype is that girls are not as good as boys in Math. The second is that scientific work is better suited to boys and men. Hill et al noted, through their presentation of various studies, that women experience "stereotype threat" which can affect their performance in tests and psychologically discourages women from developing or sustaining interest in STEM subjects. Stereotype threat, coined by researchers Claude Steele and Joshua Aronson (1995) and can be defined as "the risk of confirming negative stereotypes about an individual's racial, ethnic, gender or cultural group. Hill et al (2010) recommended that the effect of stereotype threat can be reduced or eliminated by "exposing students to female role models in Math and Science" and " making tests fair" and devoid of gender mentions.

The report by Hill et al also analysed self-assessment as a factor that influences female participation in STEM subjects. Based on traditional belief that males are superior in Math and Science, girls assess their abilities in these subjects to be lower, and this dampens their desire to embark on a STEM education or enrol in STEM courses. Self-assessment by both women and men of their abilities were almost the same in studies where there were no preconceived gender differences.

Another aspect the report highlighted was the display of spatial skills by women. Spatial skills are important in the engineering field and are used to "interpret diagrams or drawings in math and science". The report noted that women with poor spatial skills got frustrated in introductory courses which required application of these skills. Consequently, these women were discouraged from pursuing a degree in engineering. Spatial skills can be learned and will improve with training; if women are aware that training will enhance their spatial skills and are encouraged to develop these skills early in their degree enrolment, they gain confidence to continue the course.

Hill et al included departmental culture as a reason for low numbers of women in STEM. According to the report, "departmental culture includes expectations, assumptions and values that guide the actions of professors, staff and students" (Margolis and Fisher, 2002). Departmental culture is moulded to reflect a certain image on the type of people who do computer science and/ or engineering. Typically, these "type" of people are males that had an early interest in computing or physics and intensely nurtured that interest while forgoing other interests. Women who do not fit into this image feel awkward and "report lower confidence". They feel like round pegs in square holes. A more inclusive and supportive departmental culture, which doesn't have fixed expectations of how enrolled students should appear and encourages a more personal approach to integrating students into science programs, improves recruitment and retention of female students. (Margolis and Fisher, 2002; Whitten, 2002).

Faculty also play a crucial role in how female students perceive the course environment. Women are grossly underrepresented in faculty for STEM subjects. Hill et al reports that this leads to a sense of not belonging, and often these females are not included in professional or social interactions. This affects job satisfaction and subconsciously portrays to female students a dire and unwelcoming environment in science fields. A lack of mentoring opportunities both for female faculty and, in turn, female students can affect the decision to enrol in and remain in science courses.

2.4 ANALYSIS OF STUDY 2

This study examines the prolific research on the topic carried out in the United States. Some insights have been provided as some of the reasons affecting women in navigating a career in STEM. The extent to which findings, typically bias against women, are applicable to Africa is yet to be determined through surveys and interviews of the population to be sampled in Africa.

In proffering solutions, contributors of research may be caught in the socio-political web in which the academia and government may sometimes make it far easier to secure support for quick fixes that attack symptoms such as behavioral and cognitive bias than it is to find the political will to confront the root ailment of an elaborate education structure that affects the under-representation of women in STEM. An assertion by Hills et al on the importance of exposing students to female role models seemingly contrasts with their position that tests can be made fair by eliminating gender mentions.

A significant point though, identified in this research by Hills et al is that the attainment (or lack of attainment) of spatial skills early in the degree affected how women viewed further pursuit of the degree. More importantly, the report recognises studies and research which highlight that spatial skills could be improved through training. Essentially, the grasp of spatial skills was not innate or restricted to male comprehension and could be learned.

2.5 STUDY 3

White and Massiha (2016) examined a wide array of literature on studies that focus on the challenges women in the STEM field encounter and presented recommendations for future studies and a conceptual framework for persistence in STEM. In the USA for instance where women make up 47% of the US workforce and 50% of bachelor's degrees were earned by women, women are still underrepresented in science and engineering. Minority women comprise fewer than 1 in 10 scientist or engineer. Although discipline - specific causes have not fully been studied, graduation rates of women vary across various STEM fields. For example, women accounted for only 11% of computer engineering degrees but there are 43%, of bachelor's degree in environmental engineering. The authors state that studies such as McLoughlin's 2005 study on gender bias in undergraduate engineering and Hawk's and Spades' 1998 studies on men and women in engineering balancing work and family roles highlight the importance of careful construction of survey questions so as not to elicit negative feelings in women.

From their assessment of the wide collection of literature reviewed, White and Massiha highlighted some challenges women face in STEM education especially during the early years of college.

- Self-confidence: Lack of self-confidence as compared to their male counterparts. This mostly occurs in the first years of college when struggling to deal with acceptance into the academic major. Also, other factors such as loss of interest, discouragement, perception of low grades even when they actually perform well, feeling of isolation and unapproachable faculty.
- Self-selection: Qualified candidates rather go into other non- STEM majors.
- Work and home balance: Women struggle with the need to balance home and work demands. Men and women both consider their careers, but women are more inclined to family values and parenting responsibilities.
- Self-perception and competence: Although women may have advantageous factors such as, great SAT or high school scores, educated parents and family, college degrees, and understanding of the sciences, their lack of self-confidence as influence by societal and cultural factors, affects their competence.

The authors conclude by specifically recommending an approach to tackling the effect of the rigor of STEM curricula during the early years of college by investigating indicators such as interaction with other students, with professors, studying and completing and assignments and learning new concepts. More programmes designed to improve retention, should incorporate these indicators.

Rosemary L. Edzie (2014) cited the following factors as affecting enrolment numbers of females in science programmes in America: " (a) a lack of female students' understanding of the career opportunities available to them, (b) a misunderstanding of what STEM education is, (c) a lack of female mentoring opportunities, (d) low numbers of females teaching advanced math and science courses, (e) females' perception of their ability to succeed in math and science, (f) personal feelings of intimidation surrounding advanced math and science requirements, and (g) a loss in confidence in excelling at math and science" (Dave et al., 2012; Committee on Maximizing the Potential of Women in Academic Science and Engineering, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2006; Rinn, McQueen, Clark & Rumsey, 2008).

2.6ANALYSIS OF STUDY 3

The study by White and Massiha touches on an important factor that is often alleged to be the causes of the underrepresentation of females in STEM in Africa. This is the role played by social and cultural norms and for women in Africa these pose a challenge for entering and being retained in the field. Social norms not exclusive to those relating to the household but to communities and generally those that emerge within and outside of the academic or professional settings. Male faculty, and male colleagues and even some female faculty may naturally perceive women as unfit or incapable of being in such a field thus negatively affecting women's self-confidence, interest in the field, performance and even growth prospects for those already pursing the career.

The persistence framework developed in the article of White and Massiha will aid studies on how societal and attitudinal factors influence women's decision to stay in STEM. These authors have recommended that since a strong link between persistence and retention has been established, there is a need to go into deeper investigation to understand the intricacies of factors that affect women's retention in STEM. The authors conclude by specifically recommending an approach to tackling the effect of the rigor of STEM curricula during the early years of college by investigating indicators such as interaction with other students, with professors, studying and completing assignments and learning new concepts. More programmes designed to improve retention, should incorporate these indicators.

2.7 STUDY 4

Badaki (2019) attributed Nigerian women's underrepresentation in infectious disease research in Africa to male chauvinism because men dominate senior positions such as fellows and principal investigators and the other factors arising from religious and cultural fundamentalism. Evidently, non - leadership of women in research affects the prioritization of clinical research agendas which more often than not, concerns diseases and health issues affecting women.

Similarly, Opara, 2015 focused more on individual and social factors, especially societal expectations of women. She blamed the underrepresentation on traditional cultural constructs, derogatory and discriminatory stereotypes and gender biases in the education system which favours education of men. She also identified the provision of effective resources in teaching and learning as a solution.

In the UNESCO global monitoring report, the number of women who study STEM related courses at tertiary level are at low percentages. For instant in Niger 30% of women study engineering, while in Mali only 6% of women study engineering. "After leaving university, only 10% of the engineering workforce is female in South Africa and 8% in Kenya".

In data obtained from Bunting *et al.* (2014) and Academy of Science of South Africa [ASSAf], (2012), it was observed that in the 2009 – 2010 academic year in ten African universities, more females enrolled in education and humanities than in the sciences (cited in Okeke et al, 2017).

Okeke et al (2008) also noted that in Swaziland, now called the Kingdom of Eswatini, female graduates in engineering and technology went down from 12.5% in 2000 to 7.7%. Low income countries have more men than women enrolled in tertiary institutions. "In some countries, including Afghanistan, Benin, the Central African Republic, Chad and Niger, fewer than 40 women were enrolled for every 100 men." (UNESCO Global Education Monitoring Report 2016 Gender review)

Other factors adduced from research in Africa for the underrepresentation could be categorised into five:

a) Educational factors: The teaching and learning of science is not effective, resources are not available and the high cost of persistence and retention in science studies results in the attrition.
b) Institutional factors: University departments and research institutions are often headed by men. These long-standing traditions of a sort are detrimental to the professional prospects of women scientists. Also, these institutions lack suitable programmes to recruit and retain women scientists.
c) Lack of family friendly policy frameworks: There is a lack of family- sensitive policies especially at workplaces. For example, there are no baby changing stations or day care facilities at work. Also, there is no guarantee of re-entry after a woman starts a family. As a result, women scientists often cannot advance in their careers and subsequently leave the profession.
d) Individual and social factors: Lack of professional development opportunities and societal expectations of a woman contributes to a decline in women's participation in the science and technology fields.
e) Lack of implementation: A lot of policies formulated around these studies are yet to be implemented.

2.8 Analysis of Study 4

In Africa the reasons for the uneven representation have been identified as cultural and religious fundamentalism as well as lack of adequate resources in education. The lack of family friendly policies and the non-enforcement of solutions to forestall the under-representation in STEM are important highlights in theses study.

On religious fundamentalism however, it is difficult to understand how this assertion corresponds to Africa as a continent. Judging by UNESCO's study (See Table 1 above), the percentage of women in some parts of Northern Africa, presumably with a higher number of religious extremisms, are correspondingly high compared to other parts of Africa.

There is nothing documented to show that men should be privileged over women, it is only assumed to be the case. If education resources are deficit, then both men and women ought to be affected. Deficiency in educational resources does not explain why there are fewer women than men taking up STEM.

3.0 Factors That Influence the Pursuit of Science Career by Women

So far, we have examined the body of literature that exist on why women are underrepresented in Science. Although the studies were carried out by different people and at different times, they all seem to be in agreement that the underrepresentation of women in science are due to a combination of various factors.

In this section, the paper will highlight the major factors that affect the participation of women in science careers. These crucial factors play a defining role in how women perceive STEM careers and whether or not they choose to embark on STEM careers. The factors include societal stereotypes, myths that exist about STEM, the influence of intrinsic and extrinsic motivation, mental mindsets and paradigms, finding the balance between work and family and the inefficient mode of teaching and transferring knowledge of STEM to students.

A detailed analysis of the factors is presented below.

3.1 Societal Factors and Stereotypes About Women That May Affect Their Uptake of Science Career

Globally, access to education at all levels, for girls and women has been low. However, since the inception of the Millennium Development Goals, there has been significant results from efforts in closing such gender gaps. Also, there are quite a number of social factors, cultural factors and stereotypes that contribute to a girl's access to education which in turn can affect or influence their decision to take up a STEM career later on. Some of these factors that affect women taking up science include perception of women as being inferior to men and therefore unable to cope with the difficulties involved in STEM, conception of STEM subjects as a masculine career path, unaffordability of a course in STEM because of low family income, living in violence or conflict zones, child marriage, and other household demands, among other factors.

According to the World Bank, 130 million girls between the ages of 6 and 17 are out of school and half of 15 million girls who are of primary school age will never enter the classroom. A case in point is Nigeria, only 4% of girls in the North-West zone can read whereas 99% of girls in the South-East zone can read. Putting an end to violence against women and child marriages can increase the prospects of girl's access to education and completion at the tertiary level.

3.2 Myths about STEM: Around the world, cultural and societal norms deem STEM careers (especially in the technology and engineering fields) to be more suitable for men

According to UNESCO'S document, Cracking the Code: Girl's and women's education in STEM (2017), girls are brought up with the notion that STEM is a man's field rather than a woman's but this document states that research has found none or a little difference between a boy's and girl's cognitive abilities. There are only differences among people in the same sex but not necessarily between men and women.

UNESCO's opinion conforms to the school of thought that attributes differences to socialization practices – differences are called a social construct, bias and prejudices, artifacts and mistakes in the research. This school of thought conflicts with another school of thought where overwhelming evidence generated from new technologies, such as brain imaging studies, show differences that stretch beyond the reproductive domain (Goldman, 2019) and are not age restrictive either. These studies indicate that there are sex associated neuroanatomical differences and behaviourial/physiological differences (Halpern, 2012; Cahill, 2017; JAMA Psychiatry, 2017; Price, 2017). These differences synergize with the binary sex chromosomes where women have the XX pair whereas men are differentiated on account of their XY chromosomes. These differentiated chromosomes reflect the differentiated hormone/receptor interactions within cells and genetic types. Admittedly, there are genetic mutations that could result in chromosomal deformities.

The observed scientific and biologic patterns however show an appreciable degree of distinctiveness that debunks the uniformity theories about the sexes. Nonetheless they cannot be taken to mean that biology accounts for the underrepresentation of women in STEM. This is still unproven, controversial and would be a simplistic stand.

3.3 The role played by motivation (intrinsic and extrinsic) in choosing and persevering in science career

According to UNESCO, a meta-analysis of gender differences in occupational interest suggests that while men prefer working with things, women prefer working with people. Interest is also influenced by learning experiences at school during the earlier grades, influence of STEM teachers, curriculum and access to practice roles and mentors. Some other studies also show that the knowledge or attitude of boys/girls towards a particular STEM subject can influence their career aspirations. For example, boys showed more interest in engineering while girls showed more interest in health and medicine. In addition, the documents states that socioeconomic factors affect a person's motivation to pursue a career in STEM, as more advantaged students are more likely to go into the field. In all, internalized negative stereotypes could significantly affect a girl's interest and motivation in pursuing a STEM career.

Intrinsic and extrinsic motivation in the uptake of science careers are complementary and shaped by everyone's environment and experience. Extrinsic motivation which has a lot to do with incentives is more immediate and achievable but does not drive motivation, at least not in the long term. Once the incentive remains static, the motivation drops. Intrinsic motivation on the other hand, which is more internalised takes predominance when the environment becomes hostile and negative competition and rivalry emerges.

This is why classroom teaching should reinforce children's successes in learning. This can be done in a way that help students flourish as independent learners, who feel a sense of ownership and happiness at their inquiry led and exploratory learning achievements. How much of inquiry-based learning and motivation are practiced, as an instructional strategy, in schools are yet to be seen.

3.4 Mental Mode /Paradigm and Confidence Factors in a Male Dominated World

According to UNESCO'S Cracking the Code, research shows that girls and women tend to internalize the widespread stereotypes that STEM is more suited for boys. During the learning process and earlier stages of education, girls are mostly told that boys are better in math and science, and engineering is a masculine field. This in turn negatively influences the self-perception of their capabilities and their continued interest and confidence in undertaking STEM subjects. Some studies suggest that this happens with age and recommend that interventions to curb this should be implemented at the early learning stage. Some of these challenges discussed in the wide collection of literature have already been reviewed.

3.5 Superwoman Fallacy Vis-À-Vis the Ability to Combine Work and Family and Achieve the Equilibrium and Labour Laws - How Maternity Affects Women and Other Issues

There is an overlap between when a woman begins her professional and academic career and her childbearing or parenting years. This often poses a challenge between motherhood and workplace realities. Where flexibility in the workplace is not exercised, for women who chose to work outside of their homes (not every woman can be assumed to want to work outside their home), one thing tends to yield. Either the psychosocial and emotional development of children are sacrificed (Sroufe, 2005) on the altar of productivity and career advancement. Most times family demands, especially childbirth, means less availability of the woman to work demands. Lots of STEM firms and institutions have unfriendly policies and considerations regarding family women. As a result, most women are discouraged or have to constantly struggle to maintain a work-life balance so as not to lose on both grounds. More specifically, most workplaces lack friendly policies that guarantee a woman's re-entry and progress in her STEM career after childbirth or when she remains in the field, there are unavoidable family demands to attend to.

Some scholars have observed that African societies that are patriarchal make it particularly difficult for professional women to progress in their career and meet their family needs. This is especially so for nursing mothers who are considered to conflict interests of child demand with the home (Kandiyoti, 1988; Ituma et al., 2011). Social norms in Africa need to be researched into so that their impact could be understood in the context of women in science careers.

3.6 Competency Issues on the Teaching of the Subject and the Cognitive Demand of STEM on Learners Vis-À-Vis New Sets of Demands that Challenges the Entire Education Enterprise

Classrooms in Africa and in many parts of the world portray a prevalence of transmissive methods involving rote learning, note taking and other passive forms of teaching and learning. These methods of teaching are a mismatch for STEM subjects which do not necessarily lend themselves to the same feasibility you find in reading a novel or a poem or listening to a history lesson. Other subjects belonging to the Arts and Humanities domain are no less easy. They can only be well taught when there is a lot of room for analysis and lateral thinking. The reality is that the attention span of young people causes them to 'favour plain English and pictures over jargons and formulas' (Lockhart, 2014). The sort of sequencing, scaffolding and demystifying involved in STEM can often be misapplied by the best-intentioned teaching and this can affect students' motivation besides inducing anxiety. When students fail to connect with the lesson, a distaste or phobia for the subject can arise.

Psychologists have identified a neurological basis for Maths phobia. In the Stanford University School of Medicine in 2012, psychologists used fMRI to scan the brain of students as they performed Maths problems. They discovered an anxiety and fear similar to those frightened by a spider or snake in the brains of the students who felt panicky about Mathematics. As technology evolves over the years so should the pedagogy of competent teaching. The passive methods involved in the way some educators lecture in some African setting and elsewhere in the world is synonymous with a method described by Harry Lloyd Miller in 1927: ‘Lecturing is the mysterious process by means of which the contents of the notebook of the professor are transferred through the instrument of the fountain pen to the notebook of the student without passing through the mind of either’.

A competent teacher can make STEM accessible to students. STEM can be quite as illuminating as Arts and Humanities in a way that elicits positive energies in students. Lockhart (2014) argued that teachers can shortchange students by introducing them to Mathematics the wrong way, but emotion and aesthetic rewards can be evoked when Mathematics is taught in a manner that arouses curiosity, courage, creativity and playful excitement.

4.0 RESEARCH METHODOLOGY AND ANALYSIS

4.1 RESEARCH DESIGN

A univariate analysis was carried-out on the socio-economic and demographic factors as well as the intermediate factors in order to explore the determinants of under-representation of women in Science, Technology, Engineering and Mathematics (STEM) from the African perspective. A bivariate analysis was performed using the Pearson Chi-square in order to establish a statistical association between the various measures of equity in STEM and gender of the participants. A T-Test was also conducted to examine the gender difference in the STEM fields which is an equity issue and the results of our analyses were interpreted appropriately.

4.2 STUDY POPULATION

The 2019 study was carried out in selected African countries to investigate the representation and treatment of women in Science, Technology, Engineering and Mathematics (STEM) in Africa. Participants were selected from various geographical regions – Tanzania, Uganda and Kenya in Eastern Africa; Ivory Coast, Ghana and Nigeria in Western Africa; and South Africa in Southern Africa – to have a diverse range of responses. These participants were drawn mainly from research institutes and university communities.

4.3 SAMPLE SIZE

Eighty-nine (89) females and forty-six (46) males, making a total of one hundred and thirty-five (135) participants took part in the survey. The participants who were between the ages of eighteen (18) and seventy-four (74) years and had a minimum of Bachelor’s degrees, were from a mixed discipline but mostly graduates of Science.

4.4 SAMPLING TECHNIQUES

Non-probability sampling techniques were used in this research. The consecutive (convenience) sampling was the method of non-probability sampling applied for this study as the samples in the various geographical locations were easy to recruit, which allowed for cost effective sampling.

4.5 DATA COLLECTION METHOD

The study employed quantitative data collection methods.

a) Questionnaire: The questionnaire was used to evaluate the study. The questionnaire consisted of both open and closed ended questions to allow the respondents give structured but detailed answers that were relevant to the research. The questions in the questionnaire were clearly stated and enabled the participants express themselves thoroughly to allow for easy analysis of the questionnaire.

b) Interviews: The interview questions which were open ended involved a face to face meeting with each person as well as a focus group involving four to eight participants. The face-to-face interviews allowed for in-depth information to be obtained from participants' experience.

4.6 Socio-Economic, Demographic and Other Characteristics of the Study Population

(A) Age

Desire for career in Science has been established as an affective status in women of career age in this study. As indicated in Table 2, some of the participants (38.5%) in the study were between the ages of 25 and 34 years. Age is an important demographic variable that may influence one's determination to build a career path along the STEM fields. The respondents that participated in the study were 18 years and above and are mature enough to take decisions as regards their career path. This finding is in line with the general trend of STEM in Africa and world-wide which indicated an increasing number of young adults desiring to have a career in the sciences. Yet, desire is not the only locus required to take up a career in Science. Why does desire lack the motivational force for an uptake and equity in Science? Desire is aspirational but teaching methodology of science could help to close the gaps between aspiration and momentum. A strategic approach in changing the status quo of under-representation in science may have to consider why career people love Science but did not study Science.

(B) Gender

The proportion of the females (66%) as shown by the findings (Table 2) indicates that the number of female respondents who participated in the study was thirty-four more than the males in number. This reflects the narrowing of the gender gap over the years, but women remain under-represented in many STEM fields. Findings from figure 1 indicated a clear gender gap in most of the STEM fields, except in the sciences and non-STEM fields where you have more representation of women than men. Therefore, there is a gender gap in Engineering, Mathematics and Technology where men are clearly in the majority. Women's continued underrepresentation in high paying jobs and esteemed STEM fields propagates occupational discrimination and contributes to the gender wage gap.

(C) Education

The findings (Table 2) indicated that about 49% of the respondents were Bachelor's degree holders, 35.6% had a master's degree, and about 14%% had a PhD degree while 1.5% were post-doctoral fellows.

Table 2: Distribution of respondents by background characteristics

Variable	Categories	Frequency	Percentage (%)
Age (years)	18-24	22	16.3
	25-34	52	38.5
	35-44	41	30.4
	45-54	15	11.1
	55-64	2	1.5
	65-74	3	2.2
	Total	135	100
Gender	Male	46	34.1
	Female	89	65.9
	Total	135	100.0
Education	Bachelor	66	48.9
	Master	48	35.6
	PhD	19	14.1
	Post-doctoral	2	1.5
	Total	135	100.0

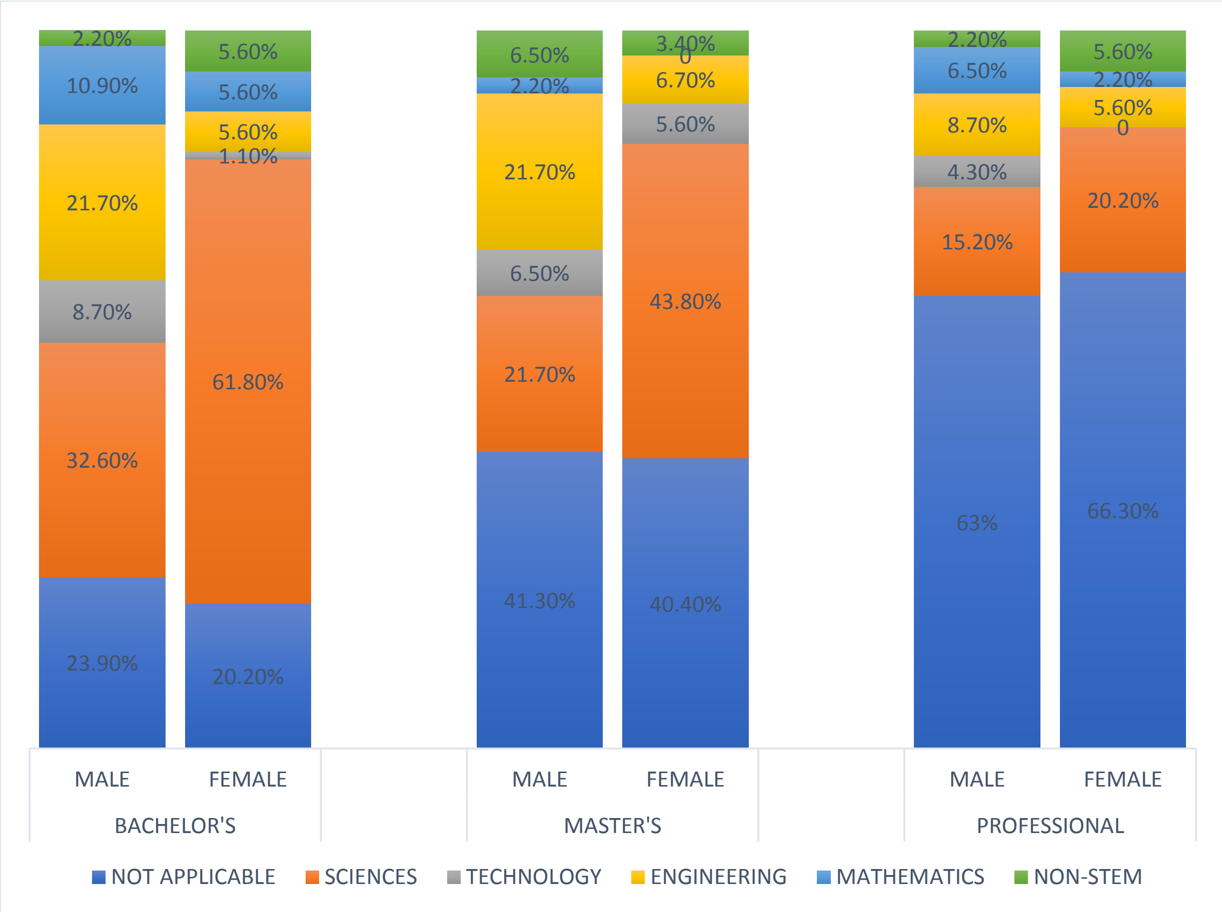

Figure1: Distribution of participants' education by gender and STEM/NON-STEM fields

5.0 RESPONSE TO RESEARCH QUESTIONS

5.1 RESPONSE TO RESEARCH QUESTION 1 WHAT FACTORS INFLUENCE THE ABSENCE OF AND CONSTRAINTS FACING AFRICAN WOMEN'S PARTICIPATION IN SCIENCE?

From the study, it can be seen that the factors which influence the absence of and constraints facing African women's participation in Science are due to their susceptibility to constraints facing women in STEM fields. Findings showed that the major factors that may influence the participation of women in STEM fields are: Firstly, the perception that STEM is a technical/difficult/stressful (26.7%) terrain. Secondly, societal belief that it is a field designed for the male folks (20.7%). In Dar Es Salaam, Tanzania, for instance, women who are doctors are referred to as nurses. However, male nurses are referred to as doctors. The word "doctor" is even considered masculine in that part of the world. Another major factor that may influence the participation of women in STEM fields is the African society and culture (15.9%). Aside fear (8.9%), choice (2.2%), non-interest (2.2%), other factors (8.10%) may also influence the participation of women in the STEM fields.

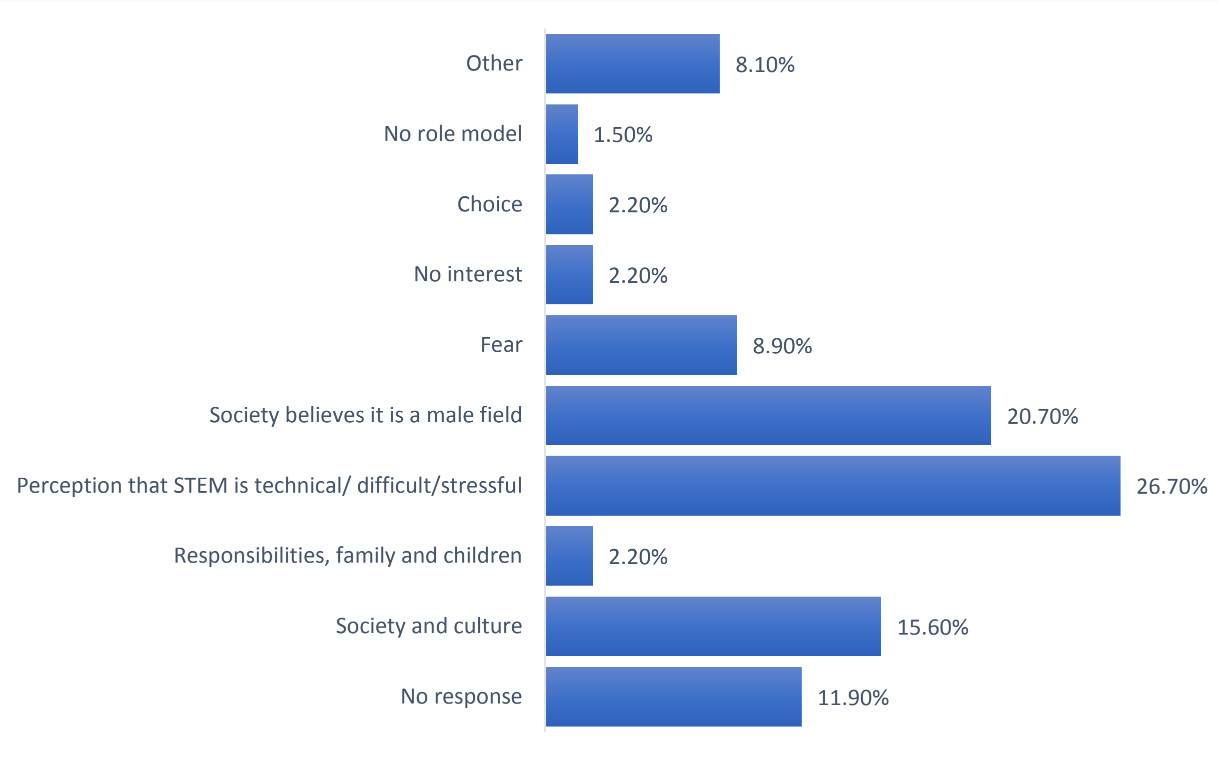

Figure 2: Distribution of factors influencing women's participation in STEM

THE EFFECT OF ENVIRONMENTAL OR LABOUR LAW ON WOMEN'S ENGAGEMENT IN SCIENCE RELATED FIELD

As indicated in figure 3, findings from the study revealed 47.4% of the participants asserted that environmental or labour laws affect the way women are engaged in science related fields while 41.5% of the participants said no. However, 11.10% did not respond to the question.

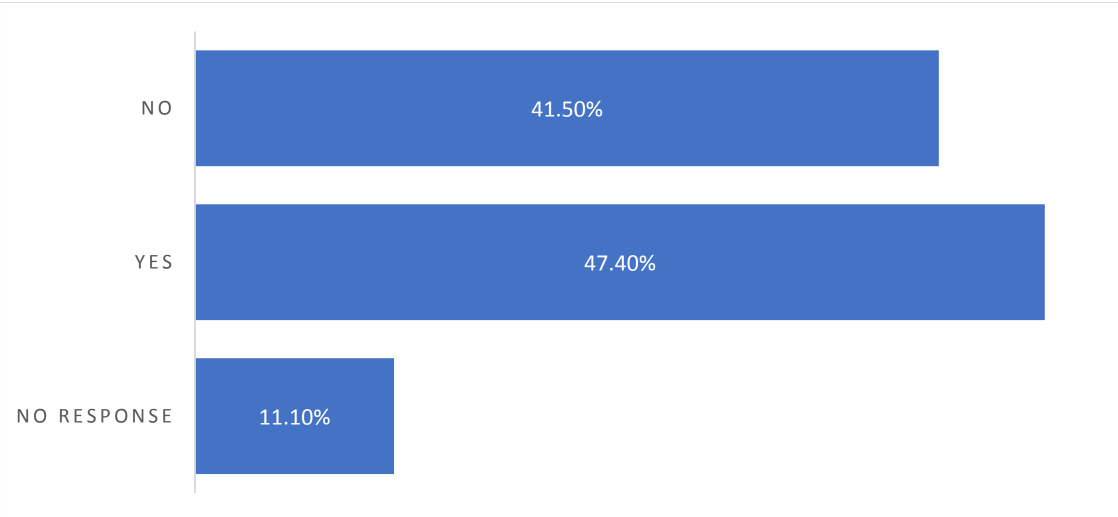

Figure 3: The effect of environmental or labour law on women's engagement in STEM field

About 27% of the participants gave various reasons for their opinions on whether environment or labour law affect the way women engage in science related careers. About 6% of the participants said laws are shaped around men's abilities, while 6.7% of the participants believed that no law exists. However, most of the participants (7.4%) affirmed that laws do not support pregnancy, maternity leave, and nursing mothers in relation to jobs. Even when there is a State law, they are not enforced, thereby giving room for private and public institution to set up their own laws with a bias against motherhood.

In some parts of Tanzania, three months maternity leave is given, usually with conditions like insisting the lady does not get pregnant within three years. If she does get pregnant within the three-year period, she will get two weeks maternity leave.

5.2 RESPONSE TO RESEARCH QUESTION 2

ARE THERE VISIBLE IMPACT AND BENEFITS FOR INCREASING THE NUMBER OF WOMEN PARTICIPATING IN SCIENCE CAREERS IN AFRICA?

Findings from the study as indicated in figure 4 revealed that there exist lots of funding and opportunities (85.9%) for women in science. Furthermore, figure 5 showed the possible reasons/benefits in encouraging women's participation in science. Findings revealed that more women are needed in STEM for growth/development of a constantly evolving society and that STEM encourages good thinking, analysing and interpretation skills among other reasons/benefits.

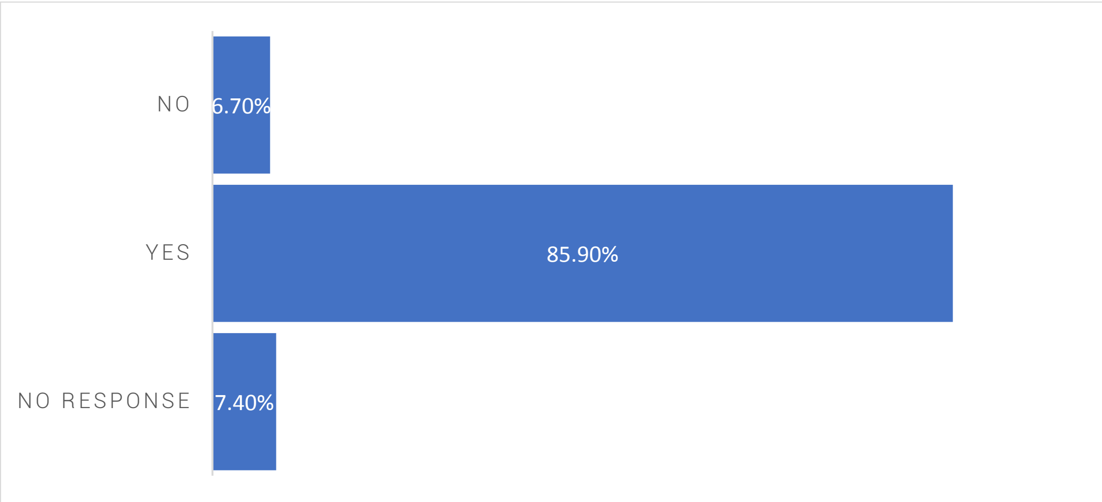

Figure 4: Existence of funding and opportunities for women in science

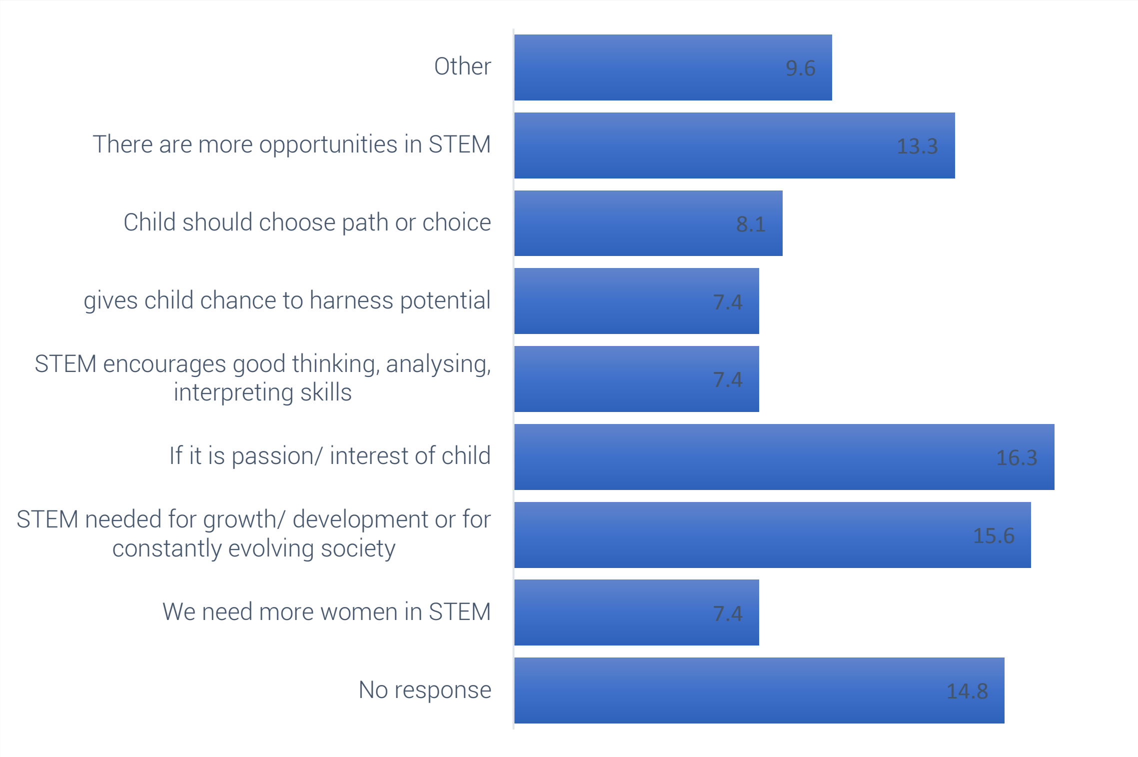

Figure 5: Reasons/benefits for encouraging women's participation in science

5.3 RESPONSE TO RESEARCH QUESTION 3

ARE INSTRUCTIONAL TOOLS FOR SCIENCE DELIVERY IN INSTITUTIONS IN AFRICA FIT FOR PURPOSE?

The results (Table 2) revealed that overall, the quality of instructional tools in African institutions of learning are inadequate in some schools but adequate in others. Furthermore, instructional tools in primary institutions are slightly adequate, while instructional tools in both secondary and tertiary institutions are neither adequate nor inadequate. The test for significant difference was carried out using one-sample t-test at test value = 4.0. The t-test result indicated that the mean difference (0.43457) is significant at $t = 2.795$, $p < 0.05$. We, therefore, conclude that the instructional tools in Africa are fit for purpose.

Results (Table 3) revealed that overall, the quality of instructional methods in African institutions of learning are on the average. Moreover, instructional methods in each of the institution of learning is also on the average. Similarly, a test for significant difference was carried out using one-sample t-test at test value = 3.0. The t-test result indicated that the mean difference (-0.06173) is not significant at $t = -1.025$, $p > 0.05$. We, therefore, conclude that the instructional methods in Africa are not fit for purpose.

Table 3: Mean responses and standard deviation (SD) of respondents on instructional tools for science and technology delivery in institutions in Africa

N=135		INSTRUCTIONAL TOOLS			
S/N	How would you rate instructional tools for science and technology delivery in institutions in Africa	MEAN RESPONSE RATING			
		MEAN	SD	CATEGORY	Remark
1	Primary institutions	4.52	2.00 3	5	Slightly adequate

2	Secondary institutions	4.43	1.907	4	Neither adequate nor inadequate
3	Tertiary institutions	4.36	2.031	4	Neither adequate nor inadequate
4	Overall	4.43	1.806	4	Neither adequate nor inadequate

Source: Researcher's Field Survey 2019. SD=Standard Deviation. Category: 1= extremely inadequate, 2= moderately inadequate, 3=slightly inadequate, 4=neither adequate nor inadequate, 5=slightly adequate, 6=moderately adequate, 7=extremely adequate.

Table 4: Mean responses and standard deviation (SD) of respondents on instructional methods for science and technology delivery in institutions in Africa

N=135		INSTRUCTIONAL METHODS			
S/N	How would you rate instructional tools for science and technology delivery in institutions in Africa	MEAN RESPONSE RATING			
		MEAN	SD	CATEGORY	Remark
1	Primary institutions	2.99	.842	3	Average
2	Secondary institutions	2.90	.813	3	Average
3	Tertiary institutions	2.93	.852	3	Average
4	Overall	2.94	.699	3	Average

Source: Researcher's Field Survey 2019. SD=Standard Deviation. Category: 1= excellent, 2= good, 3=average, 4=poor.

5.4 RESPONSE TO RESEARCH QUESTION 4

WHAT DO EQUITY GOALS FOR WOMEN IN SCIENCE AMOUNT TO IN A CONTEXT OF MASS UNEMPLOYMENT, UNDEREMPLOYMENT, DEFICIT FUNDING AND LACK OF PROBITY IN FUNDING FOR SCIENCE?

(a) Do you think one gender is better than the other in STEM Fields?

The participants were asked to assert their opinion on whether they think one gender is better than the other. Findings (figure 6) revealed that 34.8% and 14.6% of the men and women respectively affirmed that they think so. However, 65.2% and 80.9% of the men and women respectively did not think that that one gender was better than the other.

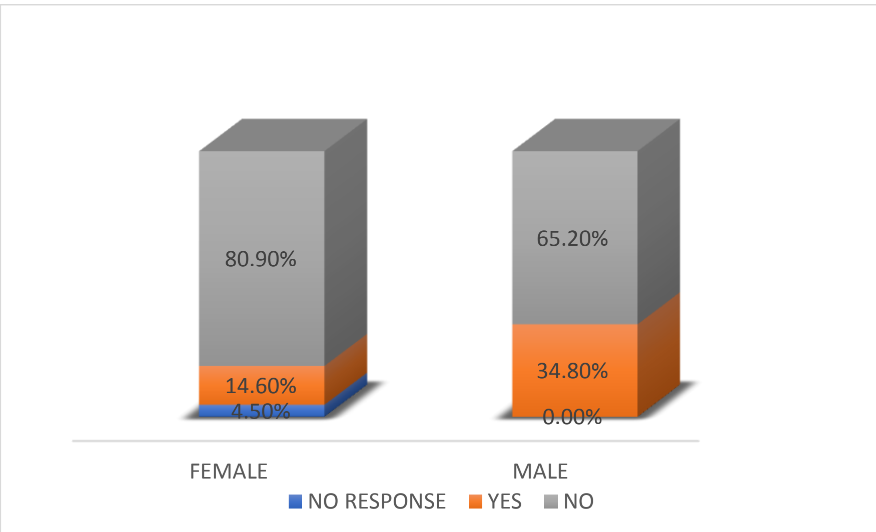

Figure 6: Do you think overall, one gender is better than the other in any STEM field?

(b) Do you feel there should be greater balance in gender representation in STEM careers?
The participants were asked to assert their opinion on whether they feel there should be greater balance in gender representation in STEM careers. Findings (figure 7) revealed that most of the participants (51.10%) did not feel that there should be greater balance in gender representation in STEM careers, while about 40% feel otherwise. Furthermore, the participants gave various reasons for their responses. The reasons most of them gave include inability to balance work with family, determination/drive to distinguish oneself, intimidation/unfavourable conditions among others.

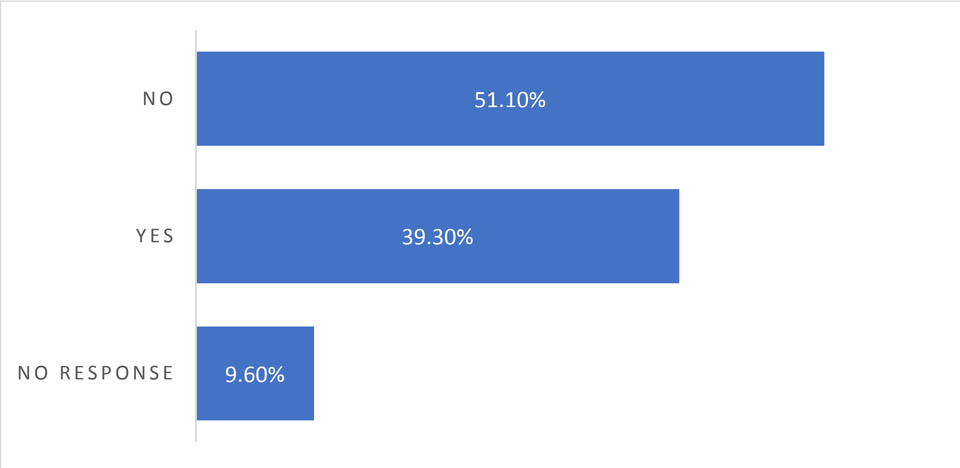

Figure 7: Do you feel there should be greater balance in gender representation in STEM careers?

(c) Factors Influencing Balance in Gender Representation in STEM Academically and Professionally
Due to the need to reduce women's underrepresentation in STEM fields, findings from the study revealed certain factors that could influence balance in gender representation in STEM. As indicated in figure 8, the major factors were increase in awareness of the value STEM in schools and communities amplified by engaging teaching methods; provision of more funding, scholarships and opportunities, encourage women to go into STEM fields, introduction of STEM in early education stages among others.

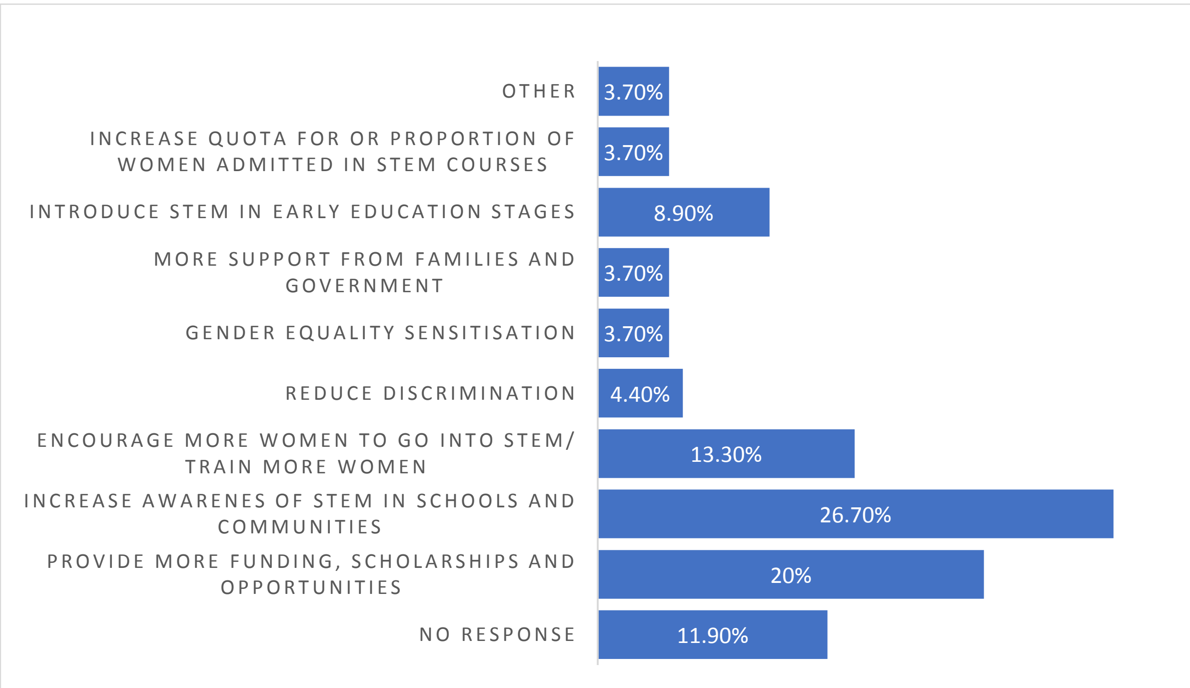

Figure 8: Distribution of factors influencing balance in gender representation in STEM academically and professionally

5.5 RESPONSE TO RESEARCH QUESTION 5

How important is equity in science, when there exist other underlying inequalities such as ethnicity, tribalism, race, area of residence, accessibility, affordability and erroneous views that treat men and women as homogenous, thereby failing to tackle the strategic gender needs of women in Science?

(a) Importance of Equity in Science
Results from the study revealed that most of the participants affirmed to the importance of equity in science as indicated in figure 9.

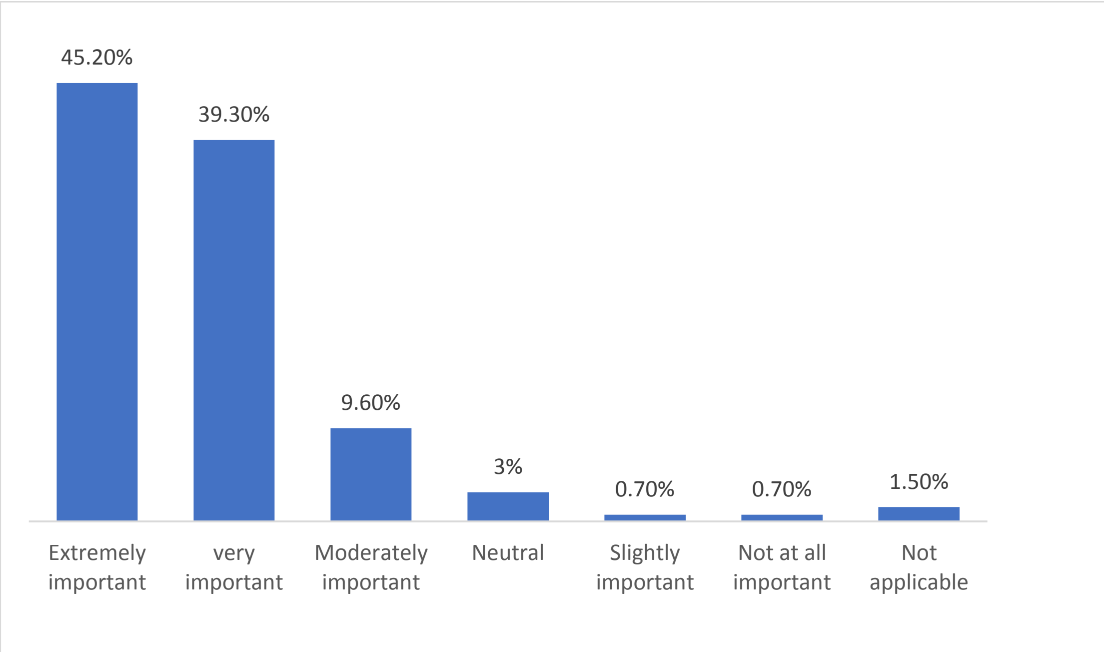

Figure 9: How important is equity in science?

MEASURES OF EQUITY IN SCIENCE

The level of equity in science was assessed through the various measures shown in Table 4. The bivariate analysis indicates no significant differences in reported equity between men and women on the two measures of equity. Pearson- chi square was used to assess the level of association between sex and some measures of equity. A relationship was said to be significant if the derived p value is less than 0.05. As Table 4 indicated, most of the participants (37.4%) were slightly satisfied with the quality of support received when studying STEM. However, there was no significant relationship between the quality of support received when studying STEM and gender, $p= 0.112 > 0.05$. Moreover, 58.5% of the participants did not experience discrimination during their academic or professional pursuit. Similarly, there was no significant relationship between level of discrimination and gender, $p= 0.256 > 0.05$.

Table 5: Measures of equity in STEM by gender

Measures	Categories	Gender		Overall	p-value
		Male	Female		
Level of satisfaction with the quality of support you received when studying STEM?	Extremely Satisfied	10 (7.4%)	1 (0.7%)	11 (8.1%)	0.112
	Slightly Satisfied	35 (25.9%)	16 (11.9%)	51 (37.8%)	
	Moderately Satisfied	28 (20.7%)	13 (9.6%)	41 (30.4%)	
	Slightly not Satisfied	8 (5.9%)	6 (4.4%)	14 (10.4%)	
	Not satisfied	8 (8.9%)	10 (7.4%)	18 (13.3%)	
	Overall	89 (65.9%)	46 (34.1%)	135 (100.0%)	
Encountering discrimination during academic or professional pursuit	Yes, encountered discrimination	40 (29.6%)	16 (11.9%)	56 (41.5%)	0.256
	No discrimination	49 (36.3%)	30 (22.2%)	79 (58.5%)	
	Overall	89 (65.9%)	46 (34.1%)	135 (100.0%)	

As indicated in Table 5, findings from the study revealed that funding and job opportunities exist for women in science, women are under more pressure to perform than their male counterparts, and that men in STEM careers regard their counterparts as inferior or weak. However, women in STEM fields encourage/cooperate with each other, as indicated in Table 5.

Table 6: Distribution of respondents by some measures of equity in STEM

Variable	Categories	Frequency	Percentage (%)
Do funding and job opportunities exist for women in Science?	No response	10	7.4
	Yes	116	85.9
	No	9	6.7
	Total	135	100.0
Given the same work conditions and level of experience, who do you think is under more pressure to perform, males or females?	No response	9	6.7
	Female	74	54.8
	Male	38	28.1
	Both	14	10.4
	Total	135	100.0
How do you think men in STEM careers regard or treat women in the same workplace?	No response	16	11.9
	Cordial/ like colleagues	14	10.4
	Inferior/ weak	47	34.8
	Equally	23	17.0
	Respectfully	18	13.3
	Tough/ manly	1	.7
	With discrimination	9	6.7
	Other	7	5.2
	Total	135	100.0

In both academic and non-academic spaces, what role do men play in women's prospects in the STEM field?	No response Bossy/dominating Leadership/ supervisory Provide opportunities Supportive/ encouraging No role Other Total	27 11 21 2 62 8 4 135	20.0 8.1 15.6 1.5 45.9 5.9 3.0 100.0

Table 7: Distribution of respondents by some measures of equity in STEM (contd.)

Variable	Categories	Frequency	Percentage (%)
How do you think women in STEM careers regard or treat other women in the same workplace?	No response Encourage each other/ cooperate Do not encourage each other Respect and dignity Discrimination/ criticism Competition and jealousy Other Total	14 51 Consequ17 18 12 17 6 135	10.4 37.8 12.6 13.3 8.9 12.6 4.4 100.0

6.0 CONCLUSION

The scarcity of women in STEM fields currently reflects a historical legacy in which women were not motivated in science-related education and occupations in Africa. Most respondents find STEM technical/difficult/stressful. STEM in schools are taught in a cognitive and regimented way. These ways of teaching and learning are prone to boredom and listlessness. Respondents from Ivory Coasts stated that Science is taught in a cryptic way because it is assumed to be a difficult subject and teachers do not teach the value of Science. Ghana noted that women are afraid of science and so opt for social science and business courses. South Africa also noted that the instructional method used to teach science in Primary school is poor, analytical and abstract thinking were not inculcated.

The findings from the research shows that it is only more recently that Science began to be encouraged in schools in Africa. In Uganda for instance, in 2005, the government launched a policy making science subjects compulsory at secondary school level and gave preferential funding to universities offering STEM. In fact, 75% of government scholarship were provided for students who studied Science (Moes, 2009). In 2011, the government in Uganda reformed the A 'level curriculum to include a compulsory inclusion of either Mathematic or ICT as part of students' choice of subjects (NCDC, 2013). Despite these changes, the failure rate in Maths and ICT over the years remained abysmal. The failure rate for ICT was over 30% and the failure rate for Maths was over 60%.

Table 8 : Failure rate for sub-ICT and Sub-Math in 2013 -2017 UACE exams

Year	2013	2014	2015	2016	2017
Sub-ICT	63.1%	51.3%	33.1%	31.4%	36.5%
Sub-Math	78.2%	61.8%	73.7%	75.3%	69.9%

Source: UNEB results 2013-2017

The NCDC investigation into the failure rate revealed that:

- Key textbooks were lacking
- Few computers available to teach
- Most teachers not trained to teach; they were more or less subject matter specialists.

Evidently, successful teaching can only take place when there is a simultaneous balance among content (what is taught), methodology/process (how it is taught) and resources (what is available to teach). It takes an effective successful instructor to prepare rigorously for these so that pupils are drawn in and are guided towards discovery and learning that impacts positively on their performance and future career choices.

Another significant finding from the research revealed the dichotomy between instructional tools and instructional methods. While most respondents considered instructional tools fit for purpose, it was the exact opposite with instructional methods. The fitness for purpose of tools used in teaching is also debatable because while the urban schools and private schools were well resourced, schools in the townships, provinces and rural areas were deficit. Where the tools exist, teachers are not trained in their use and due to underutilisation and poor maintenance, these tools become inoperative. Some respondents from Kenya also stated that science is so practical and deals with normal day to day occurrence in nature and as such may not require a sophistry of tools. The teacher, they contended, can always take the students out for an observation of nature and on the basis of that formulate hypothesis. This helps the students engage with what they see. Observational evidence is what leads to generating experiments, generation of scientific theories and their application in practice. Therefore, while the preferred situation is to have resources for teaching and motivating students in science, their absences are no hindrance if the teachers are knowledgeable about scientific methods and how scientific knowledge is constructed. Science requires teaching students in a variety of different, interesting and gratifying ways. Students who engaged in reasonable and well-paced lessons that balance content coverage with varied presentation techniques are the ones who are more likely to engage with science careers in the future.

Teaching the value of Science requires teaching it in such a way that demonstrates its interconnectedness with social issues. Onwu (2016) proposed a context-based teaching for science, 'the kind of relevant science education that is needed to address students' needs and interests as well as current global challenges facing humanity. The narrative calls for a shift in emphasis in science education from one that is essentially disconnected from social issues to one that is embedded in socio-scientific issues and is responsive to the demands of our time.'

There are new theories of how students learn best and how teachers teach best. These theories are enhancing education and engaging students as most of them are premised on neuroscience, intelligence and motivation. Understanding these theories and the processes involved suggests a future where teaching and learning practices can transform and benefit the learner as well as facilitate the uptake of STEM and policy making on STEM. Learning has to be multi-sensory and stimulus must appeal across the range of senses. The transmissive methods of teaching outlined and fostered by the behaviorists (Skinner, Pavlov and Thorndike) which lends themselves to repetition and reinforcement are to some extent important. These need to be matched with the cognitive constructivists' theories underpinning the works of Bruner and Piaget, the experiential learning of David Kolb, differentiation premised on the multiple intelligence theory of Howard Gardner and the insights gained from social constructivism of Vygotsky. Vygotsky's theory forms the basis for many modern theories that dwell on how the human brain appears to be particularly adapted to social interactions. To engage learners, teachers have to reinvent and reimagine learning by tapping into the principles of immersive virtual reality which is now being overlaid by calls for augmented reality. Augmented reality does not depend solely on textbooks as a static source of learning, but it enables learners to see the real world as well as virtual imagery attached to real locations and objects. Augmented reality provides learners with a rich and interactive educational experience

For teaching to foster the uptake of STEM, fundamental connections between motivation and the capacity to engage with learning needs to be prioritised. Learning needs to be self-directional, helping students to make abstractions, concretise and internalize and own their learning. Engaging students in this manner evokes a concept of ownership for their learning and a demonstration of positivity. This is compliant with the principles of positive education, a positive psychology contribution to education that provides significant evidence on how happiness about learning broadens thought processes, creativity and achievement. Positive education can occur when a teacher infuses learning with activities, sequencing and pacing that excites and energises students whilst regulating their flow of energy. With that internal joy comes fortitude, a willingness to relish the challenges of that learning activity.
Another important aspect that needs to be borne in mind is differentiation. Differentiation in education is based on the principle that students have diverse needs; multiple intelligences (Gardner, 1985); potential barriers to learning and therefore a teacher needs to vary their style to suit the different learning style of the students. Differentiation piques students' interest and offers the same learning opportunities to all.

With the right method of teaching, students' potential and choice can be optimised for the higher – order thinking that will help them thrive in STEM uptake.

Although, great importance was attached to equity in science, findings revealed there would be no need for greater gender balance for STEM careers. Some respondents indicated that attempts to address equity in STEM could be counterproductive and cause discrimination against men. South Africa and Tanzania were particularly concerned about this. In Tanzania, for a female student to go to a higher education, she is required to score at least division 3 but men are required to score division 2, which is a higher-level grade. This is to encourage female students to enrol in higher education. Tanzania in particular felt that there are no visible impacts for increasing the number of women in science careers because the results and expectations will not differ for men and women. For some respondents in Kenya the emphasis on the girl child might be counterproductive and maybe a contributory factor to boys dropping out of school, resorting to drugs and becoming nonentities. Accordingly, a female respondent in Kenya stated that 'a lot exists for women more than for men, so the men complain. Funding, scholarships are usually for women only and none for men and this is a bias against the men – discrimination against the men'.

The cultural factors were not prioritised by most respondents as the overriding determinant. In the past, culture was a main hindrance because of the physical strength required for some careers in STEM. Long working hours and night shifts affected family/work balance and education of men, who are considered to be bread winners, was prioritised over the education of women. A number of things have changed. Physical strength may not be an obstacle anymore because of technological development. The promotion of women in science in most parts of Africa is so intense that the percentage of women has increased whereas men are dropping out of school in some parts of Nigeria and Kenya. They drop out to pursue self-employment and quick business for immediate gratification.

Generally, most respondents agree that having women in the science career would bring the feminine perspective to a workplace that is generally male dominated.

Regarding measures of gender equity in science, findings revealed that even if funding and job opportunities exist for women in science, women are under more pressure to perform than their male counterparts, and that men in STEM careers regard their counterparts as inferior. However, women in STEM fields generally encourage one another although, this is not so in all cases. Some female and male respondents acknowledged awareness of antagonism of women by other women in the workplace. This was in line with study 1 analysed earlier in the paper, which indicated that women created an unwelcoming environment for other women.

To the perception that girls do not like STEM, findings have shown that this is more of a perception than a researched fact and it would be interesting for future research to explore the way teachers teach STEM even at an early stage.

MENTORING

Mentoring dominated the discussions that followed the presentation on the 'African Women in STEM – Paradigms and Limitations' at the 3rd International Conference for Women in Leadership Position in Higher Education (WoLPHE, 2019) themed Women's Participation in Science Programmes in Africa. Participants could relate with the findings and analysis but they insisted that mentoring would be a transformative solution to address the glass ceiling facing women's participation in STEM.

Mentoring is an authentic relationship or a supportive forum between a mentor and a mentee. The mentor, who is more experienced, provides continued career orientation and professional development. Mentoring is a voluntary activity because the choice of career and progression is the ultimate responsibility of the mentee. The mentor's role is to build a greater self-awareness and optimisation of the mentee's skills and goals. Therefore, the focus should not just be on developing competency but also facilitating emotional intelligence – character development.
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A possible substitute for mentoring is the term 'developmental network' (Dobrow, 2012; Kram and Higgins, 2001; Kram and Higgins, 2013). Development network is building a cadre of people who have the best interest of the mentee at heart and can advise mentee accordingly. Your developers according to Kram and Higgins (2013) are :

- People who help you get your work done
- People who help you advance your career
- People who provide persona; support for you
- People who are role models One benefits from the variety of perspectives provided by such a network.

They also asserted that such networks are also people who are well connected in your organisation, their organisation or in the industry. They have access to power.

In thinking about mentoring therefore, one needs to think beyond the traditional one-on-one mentor: mentee relation known as mentoring dyads and consider mentoring as an access to across diverse networks of people.

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