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# Examining the Gender Gap in STEM (Science Technology Engineering and Mathematics): A Case Study on Selected Schools

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**Abstract**
The study aims to examine the gender gap in STEM education by investigating the impact of teacher training on reducing the gender gap in STEM education, evaluating the effectiveness of mentor-ship programs for supporting girls in STEM education, and identifying the key factors that lead to girls dropping out of STEM programs in high school. The study revealed that, teacher support includes speaking to students as equals, providing equal opportunities to all genders. Teachers should assume that everyone is interested in STEM and structure lessons accordingly. Providing teachers with more engaging and relatable STEM curriculum, such as labs and hands-on projects, the kinds of activities that have proven to help retain girls' interest in STEM over the long haul. Gender stereotypes and lack of role models affect girls' interest in STEM from an early age. Yet, even when women get STEM degrees, many do not pursue STEM jobs. Gender discrimination and bias at work also discourage women from entering or remaining in STEM jobs. One way to combat this issue is by having women who are already established in STEM fields mentor girls – which offers a multifaceted approach to expand their STEM choices by introducing role models, building support systems, and providing knowledge about STEM topics and opportunities. Girls begin losing interest in STEM around age 11, a trend that worsens throughout secondary school. The reasons range from peer pressure, to a lack of role models and support from parents as well as teachers, to a general misperception of what STEM careers look like in the real world.

**Keywords:** Gap, STEM, Gender

## 1. Introduction

### 1.1 *Background*

At independence Zambia had one of the most poorly developed education systems of Britain's former colonies, with just 109 university graduates and less than 0.5 percent of the population estimated to have completed primary education. Among these, African women were almost entirely absent. The country has since invested heavily in education at all levels. Compulsory primary education begins at seven years of age and lasts for seven years. Secondary education is divided into two cycles, the first lasting two years and the second lasting three years. More than two-thirds of adult Zambians are literate, although the rates of literacy are significantly higher among men than among women.

The University of Zambia was opened in Lusaka in 1966 and graduated its first students in 1969. The university offers courses in agriculture, education, engineering, humanities and social sciences, law, medicine, mining, natural sciences, and veterinary medicine. The basic program is four years, although engineering and medical courses are of five- and seven-years' duration, respectively. Copperbelt University, formerly a part of the University of Zambia, achieved independent university status in 1987 and is located at Kitwe. It offers courses of study within its business, built-environment, natural resources, and technology schools. The language of instruction for both universities is English. Honey, M., Hilton, M. and Schuck, J. (2014) [10].

Other tertiary-level institutions are vocationally focused and include the Evelyn Hone College of Applied Arts and Commerce and the Natural Resources Development College, both in Lusaka, and the Zambia College of Agriculture and Northern Technical College, located in Monze and Ndola, respectively.

**The education system of Zambia**

The development of societies has been ever dependent on education infrastructure since the beginning of human civilization. From Aristotle to Abdul Kalam, education has been an integral part of human development. This is true for all modern societies including the ones of developing African countries like Zambia. The Zambia education system like many other developing African countries, including Nigeria, is divided into five sections – primary, middle, secondary, tertiary, and vocational. In order to better understand the nature and scope of the tier system of education in Zambia, we need to delve deeper into these five divisions.

**Education System**

The primary education section under the Zambia education system is comprised of the typical 7-5-4 format that is quite common as the basic education format for most African countries. This means those students within the Zambia education system usually complete 7 years of primary education, 5 years of secondary education, and 4 years of college or undergraduate education. However, the drop-out rate witnessed in Zambia has been reportedly quite high as most students simply complete their initial 2 years of secondary education and begin to seek employment. (Eagly, A.H. and Wood, W. (2013) [7].

**Gradual progress and development of Zambia Education System**

UNESCO has been closely involved with the recent developments taking place in the Zambia education system. UNESCO's Agenda 2030 has initiated the Capacity Development for Education (CapED) Programme, which has been associated with the Zambia Ministry of General Education in order to generate a national framework to develop the teaching force and set certain specific targets for the education system in the country. These targets are aligned towards the improvement of knowledge, skills, and general competences of Zambian teachers.

**Sciences, Technology, Engineering and Mathematics in Zambia**

According to Ramli, Ibrahim, Bunyamin, Jamaluddin, Abdullah and Surif, STEM education is an interdisciplinary approach to education that applies concepts of Science, Technology, Engineering and Mathematics to overcome high-tech industry economic challenges. It is an approach to education that integrates the four disciplines, namely, Science, Technology, Engineering and Mathematics. Further, Hernandez, Bodin, Elliot, Baharuddin, RamboHernanfez, Chen and de Miranda contend that this integration is also known as a metadiscipline, the creation of a discipline on the integration of other disciplinary knowledge into a new „whole." This means that through STEM education, learners are given opportunities to engage into scientific investigations through hands-on activities and experiments. Consequently, STEM education provides the skills needed by learners in order to successfully meet the 21st Century challenges. According to Diana, Turmudi and Yohanna, STEM education is an approach to learning which promotes the 4C skills: Communication, Collaboration, Creativity and Critical Thinking. This requires appropriate and intensive training of teachers to ensure that they know when and how to teach using specific methods. To this effect, teachers" readiness to implementing STEM education needs to be investigscience. Archambault, I., Eccles, J.S., and Vida, M. (2012) [1].

One of the major setbacks for the successful rolling out and effective delivery of a project/ competency-based curriculum in Africa is the lack of the necessary physical and material resources, and the problem is particularly acute in previously disadvantaged communities, including rural areas. Due to their nature, STEM subjects require dedicated resources in addition to the generic ones required for any other school subject. These resources include laboratories, laboratory equipment (e.g. oscilloscopes, microscopes, an spectrophotometers) and consumables. In addition to a lack of basic resources, most STEM learners on the continent do not have access to computers and related ICT infrastructure. There needs to be collaboration among academic institutions, industry, private sector, government, and non-governmental organizations to achieve this. Industry's role cannot be over-emphasized since competence based education is about relevant competence for industry and life.

***1.2 Statement of the Problem***

STEM education in Zambia has been recieved with high expectation from the pupils. Though the reception gender has become a foctor among the learner. Zambia is a among the Zambia African countries as a result the issue of gemder in education is still a war to restle against in education. According to the UN report, Women hold only 20% of jobs in the STEM sector and they comprise only 16.5% of inventors associated with a patent. Not different from zambia the gap on gender cannot be overphasised. One of the major criticisms of STEM has to do with the gender disparity in learners who graduate with STEM and enter careers related to these fields. The study the assess the gap in the STEM related subject.

***1.3 Objectives***

***1.3.1 General objectives***

The main objective of this study was to examine the gender gap in STEM (science Technology Engineering and Mathematics) Education.

***1.3.2 Specific objective***

1. To investigate the impact of teacher training on reducing the gender gap in STEM Education.
2. To evaluate the effectiveness of mentorship programs for supporting girls in in STEM education.
3. To identify the key factors that lead to girls dropping out of STEM programs in high school or college.

***1.4 Research questions***

1. What impact has been brought about in education by training teachers on the gender gap in STEM education?
2. What is the effectivenes of mentorship towards girl child on STEM education?
3. What are the keuly factors that lead to girls dropping out of STEM education?

***1.5 Theoretical framework***

This study was guided by three theories in education which include: the triple Helix theory, social learning theory and Gender Schema Theory.

***1.5.1 Triple Helix Theory***

Helix Theory of Innovation. Scholars such as Galvao, Mascarenhas, Marques, Ferreira, Ratten view this theory as a lens through which evolving relationships between academia, industry and government can be analysed. However, according to Etzkowitz and Leydesdorff, it can also be a policy making tool, an aspect that makes this theory relevant to this study. Contextualizing this theory into the current study, one would argue that before a programme is rolled out for implementation, there is need for stakeholder engagement. The role of the academia is to provide education to individuals and to do research which should inform policy. Further, the academia is supposed to provide research on which industry will build upon to produce goods and services. This could be done through conferences, formal and informal communication and article publications. On the other hand, government should provide funding to institutions that are still funded. This would ensure the academia has support in terms adequate teaching and learning material, infrastructure and funding for research. This means that there should be closer ties between academia and government.

### *1.5.2 Gender Schema Theory*

Gender schema theory is a cognitively based theory that uses an information processing approach to explain how gender development occurs. The basis of this model is the cognitive representation called a schema. A schema is an organizing structure that helps simplify and categorize new information. There are two types of gender-related schemas (Martin 1981). The first is a general 'superordinate' schema that helps children categorize objects, characteristics, and traits into basic male and female categories. The second is a narrower version of schema, called the 'own-sex' schema, that children use to identify and learn in-depth information consistent with their own sex. These two schema types allow children to process information about events, objects, attitudes, behaviors, and roles and, in turn, categorize these aspects in terms of masculine or feminine, or as similar or different from the child (Martin 1981).

Gender schema theorists Eccles, J.S., and Vida, M. (2012) proposed that gender schemas are developed and applied by children at an early age. In addition, it was proposed that the presence and use of gender schemas can explain the ways in which children and adults attend to, acquire, and remember information; how they behave; and the kinds of attitudes they develop (Martin 1981). Gender schemas affect which kinds of information are noticed, encoded, and remembered, with information inconsistent with the existing schema being overlooked and consistent information being processed (Signorella *et al*. 1997). Research also shows that gender schemas can guide children's preferences, toy choices, and play partner choices.

Gender schema theory emphasizes the child as an active processor of information and that the gender schemas that guide thinking also influence children's behavior. The major strength of gender schema theory is in the understanding it provides about the maintenance and power of gender beliefs.

### *1.5.3 Social learning theory*

Social learning theory, proposed by Albert Bandura, emphasizes the importance of observing, modeling, and imitating the behaviors, attitudes, and emotional reactions of others. Social learning theory considers how both environmental and cognitive factors interact to influence human learning and behavior.

This relates to an attachment to specific models that possess qualities seen as rewarding. Children will have several models with whom they identify. These may be people in their immediate world, such as parents or older siblings, or they could be fantasy characters or people in the media. The motivation to identify with a particular model is that they have a quality that the individual would like to possess. Identification occurs with another person (the model) and involves taking on (or adopting) observed behaviors, values, beliefs, and attitudes of the person with whom you are identifying. The term identification as used by Social Learning Theory, is similar to the Freudian term related to the Oedipus complex. For example, they both involve internalizing or adopting another person's behavior. However, during the Oedipus complex, the child can only identify with the same-sex parent, whereas with Social Learning Theory, the person (child or adult) can potentially identify with any other person. Identification is different from imitation as it may involve a number of behaviors being adopted, whereas imitation usually involves copying a single behavior.

## 2. Literature Review

### *2.1 Overview*

This section of the paper discusses the literature of the fourth estate. The literature explains the concept of the fourth estate, thematic areas based on the objectives and the research gaps in the literatures.

### *2.2 Concept of STEM*

STEM is an approach to learning and development that integrates the areas of science, technology, engineering and mathematics.

Through STEM, students develop key skills including:

problem solving, creativity, critical analysis iv. teamwork, independent thinking and initiative.

Digital literacy.

The global economy is changing. Current jobs are disappearing due to automation and new jobs are emerging every day as a result of technological advances.

The continual advances in technology are changing the way students learn, connect and interact every day. Skills developed by students through STEM provide them with the foundation to succeed at school and beyond.

Employer demand for STEM qualifications and skills is high, and will continue to increase in the future. Currently, 75 per cent of jobs in the fastest growing industries require workers with STEM skills. To be competitive, the Australian workforce needs people who can adapt to a changing workplace.

STEM empowers individuals with the skills to succeed and adapt to this changing world.

STEM education is a teaching approach that combines science, technology, engineering and math. Its recent successor, STEAM, also incorporates the arts, which have the "ability to expand the limits of STEM education and application," according to Stem Education Guide. STEAM is designed to encourage discussions and problem-solving among students, developing both practical skills and appreciation for collaborations, according to the Institution for Art Integration and STEAM.

Rather than teach the five disciplines as separate and discrete subjects, STEAM integrates them into a cohesive learning paradigm based on real-world applications.

According to the U.S. Department of Education "In an ever-changing, increasingly complex world, it's more important than ever that our nation's youth are prepared to bring knowledge and skills to solve problems, make sense of information, and know how to gather and evaluate evidence to make decisions."

In 2009, the Obama administration announced the "Educate to Innovate" campaign to motivate and inspire students to excel in STEM subjects. This campaign also addresses the inadequate number of teachers skilled to educate in these subjects.

**The importance of stem and stem education**

STEM education is crucial to meet the needs of a changing world. According to an article from iD Tech, millions of STEM jobs remain unfilled in the U.S., therefore efforts to fill this skill gap are of great importance. According to a report from the U.S. Bureau of Labor Statistics there is a projected growth of STEM-related occupations of 10.5% between 2020 and 2030 compared to 7.5% in non-STEM-related occupations. The median wage in 2020 was also higher in STEM occupations ($89,780) compared to non-STEM occupations ($40,020).

Between 2014 and 2024, employment in computer occupations is projected to increase by 12.5 percent between 2014 and 2024, according to a STEAM occupation report. With projected increases in STEAM-related occupations, there needs to be an equal increase in STEM education efforts to encourage students into these fields otherwise the skill gap will continue to grow.

### *2.3 Thematic area developed from objective one*

STEM Education has successfully proved that it would have develop strongly in any education system and in any country in the world, with the attention from the governors, administrators, scholars, educators, teachers, and learners. While STEM has become such an important part of the world's education, a gender gap has started to appear in STEM - related fields. "Even when females perform as well as or better than their male peers on STEM related tests or projects, females lose interest at higher rate and do not pursue advance courses, majors, and careers in Strydom, 2000) [28].

### *2.4 Thematic area developed from objective two*

The low participation rates of girls and women in science, technology, engineering, and mathematics (STEM) remain a critical issue for social scientists, educationalists, business associations, and politicians. Although international comparative studies of educational achievement indicate that girls in many countries now achieve on par with or even outperform boys in mathematics and the natural sciences, women remain underrepresented in many degree programs and occupations in STEM. Numerous studies have explored the reasons behind these different participation rates (Kelly, 2016; Wang, 2013; Wang & Degol, 2013) [11]. The studies indicate that besides factors at the individual level (e.g., interest, confidence in one's own STEM abilities, or motivational beliefs), factors at the environmental level (e.g., stereotypes about gender and STEM, parental beliefs and behavior, lack of suitable female role models) also contribute to the low participation rates of females. Measures undertaken to redress the situation should therefore focus on both causal bundles as well as their interplay. Moreover, such interventions need to start early enough, as gender differences in individual factors become larger with age. For example, girls' interest in STEM decreases more than that of boys as they progress through school (Frenzel, Goetz, Pekrun, & Watt, 2010).

Mentoring can take all these issues into consideration and can therefore be a particularly promising means of promoting girls in STEM. Various studies support this assumption (e.g., Stoeger *et al*., 2016). However, research concerning explanatory mechanisms is still lacking. Therefore, the current study focuses on these mechanisms. Within the setting of a 1-year online mentoring program for girls interested in STEM, the study examines whether suitably implemented mentoring (operationalized via relationship quality, in a program that assures the structural and organizational aspects for successful mentoring) is associated with changes in the learning environments of the mentees (as indicated by their increasing educational capital) and whether these changes in turn are related to positive developments of the outcome variables.

In the following theoretical section, we will first briefly explain why mentoring—and especially online mentoring—is a promising way to support girls in STEM. We will then introduce the educational capital approach that we use to assess the STEM-related learning environments of our mentees. After explaining a rationale for using relationship quality as one possible operationalization for successfully implemented online mentoring, we will describe the setting in which we conducted our study, the online mentoring program Cyber Mentor.

**Online Mentoring as a Promising Way to Increase STEM Participation of Girls**

Correctly implemented, mentoring addresses both individual and environmental causes of girls' low STEM participation rates. Women who study a STEM subject or work in a STEM field are particularly suitable as mentors in STEM-focused mentoring. They can act as role models and thus positively influence girls' interest, self-confidence, and elective intentions through conversations and other STEM-knowledge-building mentee–mentor activities.

However, women's low participation rates in STEM make finding suitable female mentors in the immediate vicinity of the female mentees difficult. This circumstance is exacerbated by the often very full schedules of women working in STEM professions. Such women are often very busy during the afternoon, while younger mentees typically only can meet with mentors during the daytime. Appropriate mentor–mentee matching and sufficiently frequent mentor–mentee interactions are crucial prerequisites for successful mentoring in STEM (Stoeger & Ziegler, 2012) [27]. Yet both are difficult to realize in an offline setting. It is difficult to find a sufficient number of suitably qualified women working in STEM who live near mentees and have sufficient time for meetings in person during the daytime. Online mentoring offers solutions to both problems. It is not dependent on participants' physical proximity and does not require synchronous meetings in person.

Previous studies bear out the effectiveness of online mentoring for promoting talented girls in STEM in particular on account of its mobility and greater scheduling flexibility. Stoeger and colleagues (Stoeger *et al*., 2016; Stoeger, Duan, Schirner, Greindl, & Ziegler, 2013) showed that STEM activities, certainty about career plans, and the intention to study a STEM subject developed more positively among talented girls who had taken part in a 1-year online mentoring program than among pupils in a waitlist control group. The waitlist control group consisted of comparably talented and interested girls who had also registered for the program but were only allowed to take part 1 year later. Including a randomized waitlist control group in the study design allowed positive changes on the aforementioned variables to be attributed to the mentoring the girls had received and not to the remarkable characteristics that the girls who chose to enroll in the program shared with one another prior to program participation. This empirical clarification is particularly important, because talented girls who sign up for mentoring programs in STEM differ from their peers who do not. In the latter study by Stoeger *et al*. (2016), for example, the pupils in the mentoring and the waitlist control groups both showed significantly more positive characteristics (e.g., grades, aspirations, interest in STEM, self-confidence) than the pupils in a randomly selected comparison group who had not registered for the program. Intriguingly, however, the researchers did not find any more favorable characteristics with regard to the learning environment of the female pupils who had registered for the online mentoring program.

**Educational Capital Approach**

Numerous theoretical models and empirical studies have shown various environmental factors to be important for explaining different participation rates in STEM (e.g., Ceci *et al*., 2009; van den Hurk *et al*., 2019). However, these findings do not reflect a shared theoretical framework. They are often discussed piecemeal or categorized simply in terms of the settings to which they can be assigned (e.g., school, home). The educational capital approach used in talentdevelopment research does provide a unified theoretical framework, on the other hand, by exhaustively categorizing the resources in the environment of learners in terms of their influence on learning and educational processes (Ziegler & Baker, 2013). The approach distinguishes five types of educational capital—namely economic, cultural, social, infrastructural, and didactic educational capital—that can influence learning and educational processes in different ways. We briefly introduce the five types of educational capital and report studies in which gender differences in the availability or use of the different types of educational capital (or related variables) have been demonstrated. Importantly, these findings showed that boys' and girls' respective environments were differentially beneficial for their learning in STEM.

Applied to the STEM field, economic educational capital refers to any kind of assets, possessions, money, or valuables that can be used to initiate and maintain educational and learning processes in STEM. In contrast to the other types of educational capital, the influence of economic educational capital is indirect. For example, it can be used to purchase learning materials (e.g., STEM books or an experimental kit). Research indicates that parents invest less economic capital in STEM promotion for girls than for boys (e.g., Bussey & Bandura, 1999; Downey & Vogt Yuan, 2005).

Cultural educational capital includes values, thinking patterns, and attitudes that may facilitate or hinder the achievement of learning and educational goals in STEM. A typical example of advantageous cultural educational capital is parents who value learning and education. The more positive these attitudes are, the better pupils perform (Fuligni, 1997). In light of these findings, results of studies (Moesko, 2010; Robnett, 2016) showing that parents and teachers consider girls less suitable for STEM than boys—even when girls and boys are achieving in STEM at equal levels—seem to be especially problematic. Entrenched stereotypes about STEM as a male domain thus represent negative cultural educational capital for girls (e.g., Cvencek, Meltzoff, & Greenwald, 2011).

**Mentoring**

The initial activity involved training both the mentors and mentees on mentorship, role modelling and networking. Each mentor was paired to four mentees from various backgrounds. Five formal face-to-face meetings were set for each mentor-mentee pair. An agreement on the goals and expectation of the mentorship was provided and signed by both parties. Informal sessions were unlimited and done through social media platforms, phones, SMS or through emails.

**Women in science event**

To ensure the community is engaged about the role of women in science, we held an event recognising women scientists and organised a panel discussion and focus group discussions, of which we had representatives from research institutions such as Malawi Liverpool Wellcome Trust and University of Malawi, College of Medicine, secondary students, educators and community representatives (mostly parents). The discussion topics included identifying and assessing challenges in the education system in ensuring the participation of women and increasing equality across STEM fields. It also included a discussion on how to diversify routes within education to increase the availability of high quality STEM careers, as well as encouraging recruitment and retention within these type of roles.

***2.5 Thematic area developed from objective three***

Ongoing technological change has led to a steadily growing demand for graduates from Science, Technology, Engineering and Mathematics (STEM). Based on the newest available numbers for 2015, Germany is among the forefront of producing highly-talented graduates in these fields, with 37 percent of students enrolled in STEM-associated majors in 2015. Nonetheless, this leading role is not mirrored in its share of female students in STEM fields. Less than one out of three STEM students are female, even below the OECD average (OECD 2017) [21].

The attempts to explain the persistent gender STEM gap range from earliest childhood determinants to labor-market-based explanations. Natural cognitive differences with boys being more capable in spatial vs verbal tasks (and vice versa) appear to be only moderate and weakly associated to STEM success (Spelke 2006). But despite the lack of inherent genetic gender differences, gaps start to arise in early development stages in childhood, when parents might engage in gender-specialized parenting. Such specialized parenting can lead to differentiated effects on STEM preferences, especially in the presence of opposite sex siblings (Brenøe 2018) [2]. As a result of such early influences, girls as early as 5th grade systematically under-estimate their math and science abilities (Weinhardt 2017). This development is then further reinforced by the prevalent lack in female STEM teachers acting as role models for successful STEM careers, which further deters girls from going into STEM tracks (Bottia *et al*. 2015). After school, women might anticipate gender pay gaps in STEM occupations (Osikominu and Pfeifer 2018).

Intervening policy measures typically focus on attracting women to STEM subjects, and on reducing barriers to enter

STEM studies in the first place. Examples for such interventions are role model provision through female scientists visiting schools (Breda *et al*. 2018), genderresponsive teacher training in STEM-related subjects, and targeted scholarship programs (OECD 2014). But barriers to enter STEM studies are not the only driver of the gender STEM gap, and measures enhancing access to STEM studies won't suffice, if women further display a lower persistence in pursuing a degree, and are more likely to drop out of STEM education conditional on beginning their studies (Kugler *et al*. 2017) [15].

While the gender gap in STEM drop out is not explained by observable characteristics in our data, we survey the existing literature on potentially unobservable behavioral explanations, such like gender differences in college preparation, gender differences in the willingness to compete and the role of teachers and teacher stereotypes.

Enhancing STEM persistence asks for a different set of policy measures that have to complement initiatives aiming at attracting women to STEM. We therefore close our discussion with a summary of potential candidates for efficient interventions that take the behavior Other initiatives include the introduction of Africa's Science and Technology Consolidated Plan of Action (ASTCPA) in 2006, as a high-level integration platform for the development of policies and setting priorities on Science, Technology and Innovation [STI] (Ambali, 2008; Kahn, 2008). It also provides political and policy leadership for the implementation of the Consolidated Plan of Action [CPA] for African countries (African's Science & Technology Consolidated Plan of Action, 2015). Recently, in 2015 the United Nations adopted the Sustainable Development Goals (SDGs) to be achieved by 2030, and education for females' agenda is at the center (Jatana & Currie, 2020). There have also been some efforts to introduce the Southern African Development Community (SADC)'s Gender Policy to support equal access for girls and boys to Science and Mathematics education.

## 3. Methods and Procedures

### *3.1 Overview*

This chapter describes the techniques and methodologies to be used in gathering data required to meet the objectives of the study. It also presents the methodology adopted in carrying out the study. It covers the following aspects: research design, population of the study, sample and sampling method, instruments for collecting data, procedure for collecting and data analysis. The study will integrate both qualitative and quantitative in order to be able to have substantial the findings.

### *3.2 Research design*

Research design refers to the overall strategy utilized to carry out research that defines a succinct and logical plan to tackle established research question(s) through the collection, interpretation, analysis, and discussion of data. Research designs constitute types of investigation through quantitative, qualitative. And mixed methods approaches that afford specific direction for procedures in a research study (Creswell, 2014) [6]. Thus, research design construe an approach researcher conducted in doing research. According to Creswell (2014) [6], research approaches comprises strategies and methods for research that extend the decisions from general assumptions to thorough methods of data gathering and reasoning. It comprises the joint of theoretical assumptions, strategies, and exact methods. There are three types of research approaches, which are quantitative, qualitative, and mixed method approach (Creswell 2014) [6]. Creswell (2014) [6] describes that quantitative approach construes analysis of an idea by establishing narrow assumptions and use data gathering to support or controvert the assumptions. The data are obtained from measuring attitudes, and are analyzed using statistical procedures and assumptions testing; whereas qualitative approach is establishing the significance of a certain phenomenon from the participants' point of view, and analyzing it over time. The data collection is obtained through observing participants behavior during their engagement in activities; and mixed method approach requires research and data collection from both quantitative and qualitative approach that may require logical and theoretical bases (Creswell, 2014) [6]. "A quasi-experimental research is research that resembles experimental research but is not true experimental research. Although the independent variable is manipulated, participants are not randomly assigned to conditions or orders of conditions" (Cook & Campbell, 1979) [3] During the training course, design ability and experimental activities organization skills had been developed following STEM education orientation (the results of the research has been published in the article "Fostering the capacity of designing and organizing experiential learning activities for students majored in natural science of pedagogical universities in the orientation towards stem education" by (Nguyen, 2019) [20].

### *3.3 Target population*

By definition, a population is said to be a collection of objects, events or individuals having some common characteristics the researcher is interested in studying (Moulton (1998)) [18]. This study will target selected schools in Lusaka and teachers who are under STEM. The population is fit for the study because much is to gotten from this population which will at last give right answers to the earlier raised research questions.

### *3.4 Sample size*

A sample is a subset of a population that is used to represent the entire group as a whole (White, 2003) [29]. The sample size of this study will target 50 respondents, this will include 15 STEM teachers and 35 pupils from respondents.

### *3.5 Sampling technique*

Sampling techniques these are methods that the researcher will use to sample from the population though they are many sampling technique in the research the researcher will use simple random sampling. Kombo and Tromp (2006) [14], argue that simple random sampling is a procedure in which all the individuals in the defined population have an equal and independent chance of being selected as a member of the sample.

### *3.6 Instruments of data collection*

The main research tools to be used in the study is questionnaires and interview. According to Orodho and Kombo (2002) [22], research instruments include questionnaires, interview schedules and observations. This study will employ the use of questionnaires and interview, the questionnaires which will be used to gather data over a large sample are both open-ended as well as closed questions. Semi-structured questionnaires will be used in the study to capture information from the teachers and pupils in general those in senior secondary.

### *3.7 Data analysis*

The data which will be collected in the field will be analyzed, be two kids of data will be gotten quantitative and qualitative data. Hence analysis method of this data will vary According to the type.

#### *3.7.1 Qualitative Data Analysis*

In line with qualitative data analysis, Kombo and Tromp, (2006) [14], argue that, 'The responses can be categorized into various classes which are called categorical variables,' and adds that, 'in qualitative research, data can also be analyzed mathematically. Themes refer to topics or major subjects that come up in the discussion. This form of analysis categorizes some related topics.' Qualitative data will be analyzed by content analysis. Content analysis is the systematic qualitative description of the composition of the objects or materials of the study (Mugenda and Mugenda, 1999) [19].

#### *3.7.2 Quantitative Data Analysis*

In this particular study, quantitative data is to be analyzed using the statistical package for social sciences (SPSS) and STATA to generate descriptive statistical information in form of frequencies, variables, pie-chart, tables, graphs as well as percentages. The data will be analyzed by using the pie-charts, tables, graphs and statistical measures such as percentages. Demographics of the respondents. Some data might be structured, the structured data will be analyze through content analysis in order to understand consistence of information from various respondents. Therefore, the results will be presented using frequencies, pie-chart, tables, graphs as well as percentages in form of statistics. 'Statistics are a set of mathematical methods used to extract and clarify information from observable data. Statistics generate simple numbers to describe distributions' (Kombo and Tromp, (2006) [14]. Besides, Gall *et al*, (1996) [8], states that mathematical technique is appropriate for organizing, summarizing as well as displaying a set of numerical data. The researcher used two techniques as a way of processing and analyzing data from the research findings.

### *3.8 Triangulation*

The researcher used the first type of triangulation in which a variety of sources were used to collect data. This is because the researcher used this technique to collect data from the distribution of questionnaires to the respondents. Also, the researcher might use another type of triangulation, which with may be of applicable to multiple of theories and perspectives in interpreting the data. This was through the use of other literatures, and the primary data which will be collected from the respondents.

### *3.9 Ethical Consideration*

Ethics as defined by (Strydom, 2000) [28] are a set of moral principles suggested by an individual or group, is widely accepted and which offers rules and behavioral expectations towards respondents and other stakeholders in research. During the study, the researcher observed the ethical considerations by respecting the rights and views of the participants.

The researcher is to produce a written informed consent from the Information and Communication University in order to conduct the research. White (2003) [29], cites the relevance of the information to the participants' decision as one of the most important elements in informed consent. Furthermore, the study was to ensure that information collected was to be only used for the purposes of academic research.

### *3.10 Confidentiality*

Confidentiality of data collected from participants will be followed appropriately. Confidentiality, guarantees that data linked to information to respondents, such as, names, locations of household and identification numbers will not be exposed during the study. No follow ups would be made for respondents.

Regarding respect, such as gender, socio-economic status, age, religion and ethnicity, all will demonstrated with high integrity and honesty in all the stages of the research. Respondents will not put at risk, discrimination and disadvantaged in any way due to their participation.

Besides, the researcher is to maintain the highest level of confidentiality during the study in order to protect and promote the rights of the respondents on any form of oppression due to their responses.

## 4. Presentation of Research Findings and Discussion of Results

### *4.1 Overview*

This section of the study shows the results of the study based on the objective in chapter one raised, all the findings in this section are not the researcher's view point of the study but the respondent's views. The section is in two phases qualitative and quantitative analysis, tabulation was done using STATA and Micro soft Excel.

### *4.2 Demographics*

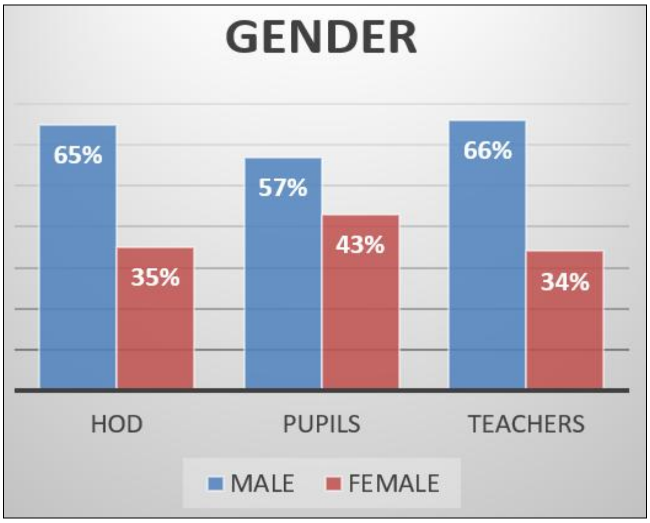
This section of the paper discusses the background characteristics of the respondents some of the data collected include: sex (gender), Age, education information, response rate, etc.

**Response rate**

Response rate is the percentage of the questionnaires /interviews respondent out of the targeted population.1.A response rate is the percentage of people who completed a survey compared to the number of people who viewed or started it 12. It is a core metric in determining whether or not a survey was successful in engaging its target audience 1. The response rate can be calculated by dividing the number of completed survey responses by the number of people who viewed or started the survey. To convert this to a percentage, multiply your final number by 100 1. The graph below shows the results as gotten from the field.

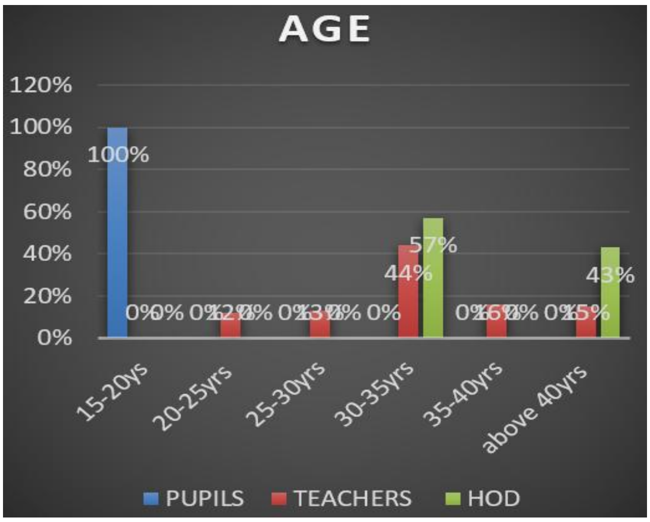

**Gender**

This section show the sex ratio according to sociologist The human sex ratio is the ratio of males to females in a population in the context of anthropology and demography. In humans, the natural sex ratio at birth is slightly biased towards the male sex. The chart



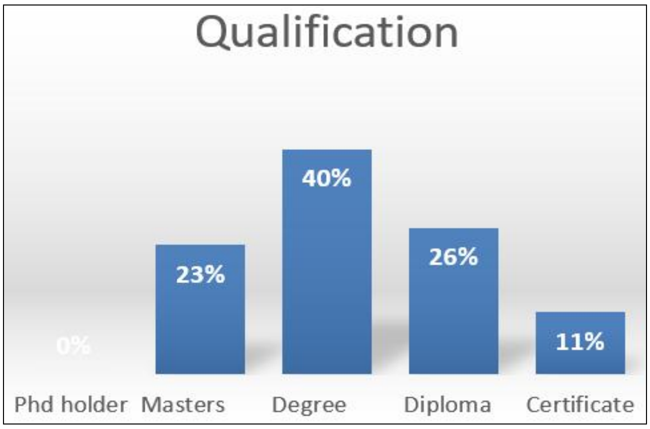

**Age**

The age of respondents was considered to help graphically present the distribution as gotten. Below is a chart showing how the age distribution was for the targeted population.



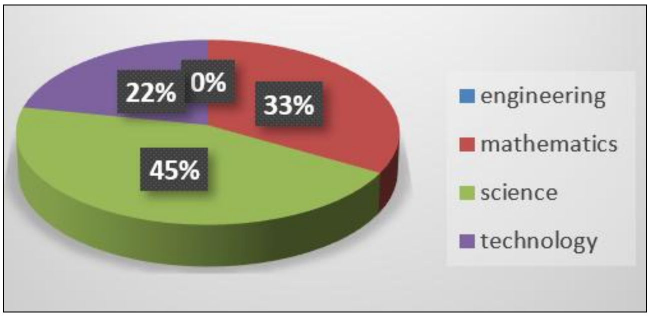

**Qualification level of the respondents**

The researcher examined respondents' formal education levels, emphasizing its historical context, evolution, and importance for economic access, leading to universal mass education ideals still unmet worldwide.




**HOD**

The researcher evaluates respondents' formal education levels, essential for understanding academic learning through structured curricula. Historically, education was limited to the elite, but rising capitalism increased its importance and accessibility. By 1900, Canada and the U.S. approached universal education, a concept still unfulfilled globally. The study aims to assess STEM education competence among teachers and HODs. Results are displayed in the graph below.




***4.3 Presentation of results based on a thematic area developed from objective one***

From the responses given, it was clear that STEM education was an approach to learning aimed at producing learners who were creative, analytical, autonomous and critical thinkers. This is in line with Ramli, Ibrahim and Svof who contend that STEM education focuses on active learning that involves a lot of hands–on activities by creating new solutions to complex problems. By implication, STEM education takes the inquiry based learning approach. By inquiry based learning approach, the learners are given an activity which makes them arrive at a given concept through engagement, explanation, exploration, elaboration and evaluation. Furthermore, learners are continually engaged in rigorous instruction, and this makes STEM classrooms different from the ordinary classrooms. By using constructivist approach to learning, learners build their own understanding of new ideas. The ideas learners usually bring are alternative to currently scientific acceptable ideas or alternative conceptions. According to Chien and Lajium, learners in STEM education are proficient in applying, creating, evaluating and critical thinking.

Critical thinking can be understood as a practice of processing information in the most skilful, accurate and rigorous manner possible for the benefit of an individual and society]. This means critical thinking skills in the learners will help them to make responsible decisions about their lives, behaviour and actions with full knowledge of the consequences and underlying assumptions of the choices made. One can also argue that STEM education has the potential to produce informed citizens who are capable of using critical thinking in making intelligent decisions about everyday challenges of life. In this vein, the teacher should ensure that the learning experiences incorporates problems which are important to the learners and not just to the education system. With this approach to education, learners are more likely to retain and transfer new knowledge to real life. Hence, STEM teachers should be seen using problem solving methods in their teaching. Problem-solving as a teaching strategy actively engages learners in practical learning activities. Furthermore, this approach to learning gives learners an opportunity to explore their environment in search for solutions to problems and challenges they encounter in society. When learners are given the opportunity to play a reading role in the teaching and learning process, they are without doubt engaged in the process of critical thinking. It is clear from the findings that the guiding principle of STEM education was centered on Outcome Based Education. A move from behavioral to constructivism pedagogy which equips learners with knowledge, skills and values.

***Learning Environment, Objectives and Pedagogical Format***

STEM focuses on teachers' actiotope for promoting gender equality in their classrooms by realizing the principles of reflective coeducation. Therefore, teachers learn about scientific findings on the emergence and maintenance of gender differences in academic motivation, achievement and aspirations, and about possibilities to reduce these gender differences through appropriate teaching methods in order to expand their current action repertoires. As teachers will only apply the acquired knowledge if they are convinced that they can implement it, their subjective action space is enlarged in the training through practical exercises and the supervised implementation of a classroom project. Teachers' environment flows into STEM as the teachers test all training contents in the classroom and discuss their experiences in the training.

Moreover, the training addresses the role of language, textbooks, colleagues, and students' parents as relevant aspects of their environment. Although STEM program is a teacher training program, it also aims at students. The intended changes in teachers' actiotopes are assumed to lead to changes in their teaching which in turn should lead to changes in their students. Therefore, these has three interrelated training goals:

Expanding secondary school teachers' current action repertoire by providing them with the knowledge necessary to change their teaching according to the principles of reflective coeducation;

Expanding teachers' subjective action space by enhancing their self-efficacy beliefs regarding reflective coeducation;

Increasing students' knowledge about the emergence of gender differences and improving their perception of diversity fairness in class.

The training program is conducted within the framework of a two-semester course. It is divided into two consecutive phases, an intensive phase followed by a supervision phase. For the participating teachers of STEM program embraces a work effort of 100 h per phase. In the intensive phase, teachers attend four modules of 2 days (à 7 h) in a university setting (56 h).

In the remaining 44 h of this phase, participants work with the training contents in preparation and follow-up processing between the modules. In the second semester during the supervision phase, teachers integrate the contents of the training into their teaching with the support of the trainers that is fading in accordance with the cognitive apprenticeship method (Collins *et al*., 1989). Training contents in the intensive phase cover an introduction to the topic of reflective coeducation (Module 1), psychological findings regarding gender differences in education (Module 2), and concrete teaching methods to reduce gender differences in the classroom (Modules 3 and 4). In the first module, the participating teachers get to know different psychological approaches to the topic of promoting gender equity in schools including the comparison of single-sex education and reflective coeducation. In addition, they are guided in reflecting on their own gender stereotypes, which is an important prerequisite for reflective coeducation. The second module deals with the development of gender differences emphasizing the nature versus nurture debate (Eagly and Wood, 2013) [7]. The main focus of the module is on the contribution of gender stereotyped socialization practices to gender development and differentiation (Bussey and Bandura, 1999). Among others, the module emphasizes the influence of parents, teachers, media, and language use (Kollmayer *et al*., 2018b) [13]. Based on this, teachers are guided to reflect on their impact on the emergence of gender differences among their students. In the third module, teachers learn to identify aspects of their teaching that can lead to the development of gender-typed academic motivation, achievement and aspirations in their students, and about ways of promoting gender equity in the classroom, for example by selecting adequate teaching materials or assigning tasks differently. The module especially focuses on how to create a climate of motivational equity, in which students are motivated to learn primarily for intrinsic reasons (Covington, 1998) [5]. Building on that, teachers are guided in designing lessons that foster individualization and autonomy and thus reduce the impact of gender stereotypes on motivation and achievement (Lüftenegger *et al*., 2012) [17]. Figure 2 highlights how the different elements of the training (theoretical input, practical exercises, and research experiments) interact to support the teachers in reaching the learning goals of the third module as an example for the general structure of the training.

***4.4 Presentation of results based on a thematic area developed from objective two level of interest in STEM program by gender***

The table below shows the mean score and standard deviation value following by the level of interest towards STEM. The table indicates, the level of all three aspects of interest towards STEM are moderately high and high with the mean scores between 3.5 and 4.3. The interpretation of the level of the mean score was based on. The level of the interest towards science is 'high' for both group and gender. This high score mean of interest towards science probably because in the early ages of learning, in this context were form one student (age 13 years old), the students have more desire or interest to know more about science. But it is feared that their interest in science decreases as their education level increases. The current issues that showed interest towards science among school students in the country. Hence, research have suggested, access of mentoring as an enrichment program or afterschool program can help to increase and maintain their interest. Meanwhile, the level of interest towards mathematics indicated the different of level in both group and gender. Boys in treatment group shows moderate level of interest towards mathematics compared to the boys in control group with high level of interest towards mathematics. This finding could not be clarified further. It may be explain clearly if the pre-test was conducted as well as a qualitative study to learn more about the cause. On the contrary, girls in the treatment group indicate high level of interest towards mathematics compared to the girls in control group. Some research shows girls interest towards mathematics declined starting in the middle school and worldwide including Zambia. However, one possibility which is contributing to increase the interest among girls is the usability of mentoring group approach. It is shows that mentoring help students to hinder from losing interest towards mathematics and provide them with the scaffold they need to develop greater interest. Based on the Table 3, interest toward engineering and technology indicate boys in the treatment group shows higher interest compared to the girls and control group. One possible reason for the low level interest among girls compared to boys is that that engineering and technology are stereotyped linked to a masculine field and machines are related to the quality valuable for boys compared to girls. However, both girls and boys in the treatment group shows higher score mean compared to the control group. The mentoring programs which involved hands-on activities and multidisciplinary STEM project in creating product, together with the support and motivation form the facilitator, may help both girls and boys to cope with the challenge in accomplished their goals of projects. Overall, boys and girls in the treatment group shows higher level of interest towards STEM compared to control group. The finding of this study does support previous finding on the positive effect of the STEM Mentoring programs on students' interest towards STEM subject. Findings showed that pupil's current interest in STEM is associated with their participation in afterschool programs such as clubs like JETS. STEM mentoring leads to a better STEM achievement than their peers who lacked such opportunities. Besides, according to, involving in face to face mentoring program is also meaningful to students socially and intellectually.

### *4.5 Presentation of results based on a thematic area developed from objective three Causes of learner dropouts*

This section presents the causes of learner school dropouts in with the views of the teachers, learners, parents and head teachers.

Views of teachers on causes of learner school dropouts in STEM programs.

Views of head teachers on causes of learner school dropouts in STEM programs.

The researcher interviewed three head teachers to assess their view on the leading causes of learner drop outs. This study discovered that though examinations were a good practice to assess the progress of learners' performance in class and during examinations were a major source of learner drop out.

Two out of three head teachers said:

> The main cause of learner drop outs was examinations especially the grade nine examinations.

For example the whole lusaka only 42.5% passed the examination. We do not know whether the other 57.5% have repeated or have dropped out of school but I can tell you majority are not in school. The school system does not have a provision to follow up those who have dropped out of school due to examinations because it is assumed there are not enough places in grade ten.

Three head teachers said:

> Teenage pregnancies have been the leading cause of learners, especially girls, dropping out of school. The most vulnerable are those girls who come from far places and rent small houses in compounds.

### *4.6 Discussion of research findings*

Honey *et al.* (2014) [10] emphasized that designers of integrated STEM initiatives must clearly define their goals and purposefully design experiences to meet them. In our study, we implemented these recommendations by setting objectives to evaluate teachers' content knowledge, self-efficacy, and integration of STEM lessons in their classroom practice. We structured professional development (PD) to support these objectives and assessed outcomes using both qualitative and quantitative data, successfully applying the STEM framework.

The primary research question focused on changes in teachers' mathematics content knowledge due to participation in STEM PD. We observed no significant performance changes on the assessment instrument used. This was attributed to a misalignment between the PD curriculum and the assessment, where the KAT subscales measured specific algebra knowledge while the PD covered broader topics like statistics and geometry. Thus, the KAT score reflected algebra knowledge alone, failing to capture integrative STEM content knowledge.

Insights pointed out the challenges of aligning curriculum standards with assessments, as curriculum integration in STEM teaching complicates the measurement of such knowledge. Research suggests the need for a targeted assessment to evaluate necessary mathematics knowledge for teaching integrated STEM lessons. A promising example is the Logarithms and pH Assessment, which demonstrated the effectiveness of integrated lessons through improved post-assessment scores, indicating the potential for advancing understanding of integrated STEM teaching methodologies.

In addressing our second research question, we noted significant increases in teacher self-efficacy, as evidenced by the T-STEM instrument. Honey *et al.* (2014) [10] identified content knowledge as a crucial factor impacting teacher effectiveness and self-efficacy. Thus, there appears to be a connection between the first and second research questions, as the professional development (PD) program likely fostered this growth. The teachers demonstrated high content knowledge, measured by the KAT, which served as a foundation for enhancing their self-efficacy levels. Notably, self-efficacy improved statistically in three T-STEM subscales, particularly in the Mathematics Teaching Efficacy and Beliefs, which assessed teachers' confidence in mathematics instruction. Rigorous and relevant PD activities aligned with iSTEM concepts facilitated deep understanding of the relationship between STEM topics and mathematics, leading to meaningful learning experiences that bolstered teachers' confidence.

Supporting findings from Green and Kent (2016) highlight the importance of collaborative relationships in enhancing teachers' confidence in teaching integrated mathematics, science, and technology. Additionally, the PD positively influenced teachers' perceptions of how their actions contribute to student achievement in mathematics, reinforcing research indicating supportive teacher practices improve student outcomes. A focus on STEM careers within the PD allowed teachers to explore resources and understand their influence on students' interests in advanced mathematics, emphasizing the importance of teacher support for effective STEM integration, as supported by previous studies (Koirala and Bowman, 2003; Honey *et al.*, 2014) [12, 10].

## 5. Conclusion and Recommendations

### *5.1 Overview*

This section of the study discuss the conclusion and recommendation of the the study based on the findings from Objective one, two, three and four the recommendations give are on the views of the researcher but not the response give by the study group.

### *5.2 Conclusion*

Tackling Gender Disparities in STEM Education

Although advancements have been achieved in closing the gender gap in STEM, societal norms and attitudes still require examination. Female students frequently question their skills in STEM areas, even though they have demonstrated equal proficiency in completing STEM assignments. Support and diverse group compositions in educational institutions can enhance self-assurance in female students. Moreover, targeted programs for female students in STEM disciplines can enhance their achievements and help diminish gender disparities. Female graduates can act as role models, yet it's important to ensure genuine gender equality is preserved without reinstating prior imbalances.

Suggestions for Enhancing STEM Education Policies

Data collection systems need to be restructured to obtain comprehensive data on student demographics and trajectories in STEM education. Educational policies must better align with the varied objectives of students in both 2-year and 4-year institutions, providing sufficient support for those studying STEM fields. Institutions of higher education, disciplinary organizations, and funding bodies ought to collaborate to strengthen STEM strategies, initiatives, and policies to enhance teaching. Accrediting bodies, state governments, and educational institutions must adopt policies that simplify and improve the transfer process for students transitioning between schools.

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