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RESILIENCY IN MATHEMATICS: INVESTIGATING THE LIFE EXPERIENCES OF SUCCESSFUL FEMALE MATHEMATICS PROFESSIONALS IN SELECTED PUBLIC UNIVERSITIES IN GHANA

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MASTER OF PHILOSOPHY

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in the University of Education, Winneba

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DECLARATION

STUDENT'S DECLARATION

I, BEATRICE TSOTSOO MARTEY, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……...

DATE: …….....

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: PROF. JONES APAWU

Signature: ……...

Date: …….....

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DEDICATION

This study is dedicated to my parents, Mr and Mrs Martey, to my husband, Mr. Maxwell Atia and to my son, Charis Atia.

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ABSTRACT

This study investigated the experiences of successful female mathematics professionals and the elements that facilitated their resilience in the mathematics field. A survey design and sequential exploratory mixed method approach were employed in collecting both quantitative and qualitative data for the study. The population for the study was female mathematics professionals in selected tertiary institutions in Ghana from which 70 females in Central and Greater Accra Region were sampled using purposive sampling technique and snowball sampling for data collection exercise. Close-ended questionnaire items and semi-structured interview protocol were used as data collection instruments. Frequency count, percentage, Pearson's product-moment correlation coefficient were the statistical tests used in analyzing the quantitative data collected for the study while the qualitative data was presented in descriptive words. The result revealed unhealthy school environment (75.71%), sociocultural beliefs (74.29%) and managing multiple roles as challenging experiences of females in their educational journeys. Also, internal factors (e.g., mathematical self-efficacy 78.57%, determination and self-confidence in mathematics 70.00%) and external factors (e.g., active participation in co-curricular and extra-curricular activities 72.86%) were common factors that contributed to females' success in the mathematics discipline. The study further found that support systems (e.g., family, school, peer, role models and scholarships) are essential factors which helped females to successfully manoeuvre their ways to gainfully attain a profession in the mathematics field. Finally, the Pearson correlations indicated a significantly positive correlation between various support systems and females' resilience in mathematics. The researcher hereby concluded females' challenges in their educational journey in mathematics are related to experiences in unhealthy school environment, sociocultural beliefs and managing multiple roles in the home. However, some internal and external factors as well as support factors contributed to their success in the discipline. Based on the conclusion, it is recommended that parents should put in much effort to develop the mathematical resilience of their female children.

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CHAPTER 1

INTRODUCTION

1.0 Overview

This chapter is organised under the following headings: background to the study, statement of the problem, purpose of the study, objectives of the study, research questions, significance of the study, delimitation of the study, limitations of the study, definitions of terms and the organizational structure of the study.

1.1 Background to the Study

Mathematics is the pioneer and the queen of all sciences (Aguele & Agwagah, 2007). In other words, mathematics is believed to be the foundation and pre-requisite for understanding the nature of modern science and technology (Allotey, 2017). Similarly, Yarkwah (2020) acknowledged mathematics as the mother of all learning since subjects in both arts and sciences stem their principles and theories from it. In the development of a nation, mathematics is recognized as an important area of learning which drive economies and technologies in every society because of its relevance in most fields including economics, sciences, liberal arts, cosmology and the list goes on (Aguele & Agwagah, 2007; Mandina, et al., 2013; Yarkwah, 2020). Mathematical chronicles emphasized that whenever society prioritizes the knowledge of mathematics, there is an immense contribution to the advancement in science and technology (Alutu & Eraikhuemen, 2004; Mandina et al., 2013). A close and careful study of the history of Romans, Chinese, Japanese, Arabs, and Indians revealed that ancient civilization is highly associated to the development of mathematics (Jayanthi, 2019). It is therefore no hyperbole to say that history of mathematics is the annals of civilization.

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In a developing country like Ghana, mathematics education must be prime. Mathematics occupies a privileged position in the Ghanaian school curriculum. One encounters mathematics as a subject all through each level of education right from the early childhood through the basic to the higher levels of education (Curriculum and Research Development Division [CRDD], 2010). The study of mathematics disciplines the mind and it is a key component for one's chances of social advancement (Fletcher, 2009). It is in recognition of mathematics' usefulness that the education sector in Ghana has made mathematics one of its core subjects to be studied by every learner at least up to the Senior High School level (Fletcher, 2009). The main rationale for the Ghana Mathematics curriculum is focused on attaining one crucial goal: to enable all Ghanaian young persons to acquire mathematical skills, insights, attitudes, and values that they will need to be successful in their chosen careers and daily lives (CRDD, 2010).

To augment the effort of the government in improving mathematical competencies and interests, primetime limited, a private communication consultancy produced the National Science and Mathematics Quiz (NSMQ) for Senior High Schools in Ghana (Primetime, 2016). The objective of the NSMQ is to help students develop a mathematical and scientific mind for thinking and probing their environment, to foster positive contribution to the nation's development (Primetime, 2016). Moreover, from the onset of the competition, the NSMQ has been hosted by women who have excelled in science and mathematics as a way to encourage female participation (Primetime, 2016). It's however surprising to know that after twenty-five years of the NSMQ, no girl's school in Ghana has ever claimed the championship title. Only two girls' schools came close to quarter finals. According to scholars (e.g., Hall, 2012; Yarkwah, 2020), the underrepresentation of women in mathematical disciplines has been prevalent over the years.

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Collective efforts were made by researchers to identify the factors for the underrepresentation of females in mathematics (Hill et al., 2010; Mandina, et al., 2013; Matete, 2022; Mukhwana et al., 2020; Wang & Degol, 2017). These researchers (Fletcher, 2009; Matete, 2022; Wang & Degol, 2017) affirmed that mathematics is largely a male-dominated field which is noted to be difficult, cold, abstruse, theoretical, and inhuman. In an analysis of gender differences in mental test scores, Halpern et al. (2007) confirmed that males achieve better results on tasks that rely on skills using spatial orientation, visualization, and some quantitative tasks than females. However, the study of Halpern et al. (2007) acknowledged some exceptions which included reading comprehension, perceptual speed, and associative memory that girls outperform the boys. Similarly, Henrion (1997) observed that in the mathematics community, there is a common belief that being a woman and being a mathematician are incompatible, one can either be a woman or a mathematician, but not both. It was also held in history that females were biologically incompatible with mathematics, thus their brains were too small, and their hormones were not compatible with mathematical development (Henrion, 1997, p. xxiv). According to Halpern (2000), males' brains have neurological qualities that make it possible for them to perform better in mathematics than females. Nonetheless, some females' continual improvements in achievement scores refute this argument and their spatial skills improved fairly easily with training (Halpern et al., 2007; Hill et al., 2010; Reilly et al., 2017).

In recent times, data released (National Accreditation Board, 2012-2018) has shown an increment in the enrolment of females in higher education (see Table 1).

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Table 1.

The total student population in tertiary institutions in Ghana

Academic year	Males	Females	Percentage of Females
2012/2013	236,649	153,248	39.30%
2014/2015	238,828	157,436	39.73%
2016/2017	255,594	176,663	40.87%
2017/2018	254,237	185,288	42.16%

Source: Tertiary Education Statistics Report

Atuahene and Owusu-Ansah (2013) asserted that though more females are enrolling in higher education, there is a mismatch in the enrolment in science and mathematics-related programmes. Boateng (2015) observed the disparity that exist within programmes that is pursued in Ghana's higher Education, and reported a low percentage of females enrolling in Science and Mathematics programmes as compared to Arts and Humanities. In addition, statistics shown by National Accreditation Board on Tertiary Education (2012-2018) revealed a low enrolment of females in mathematics and science-related programmes. The analysis (National Accreditation Board on Tertiary Education, 2012-2018) also unveiled that in the 2012/2013 academic year, only 27% of all the undergraduate females were admitted for Mathematics and Science related courses, 20% in 2014/2015 and 26% in 2015/2016. Thus, for those who get the chance to enter into higher education in Ghana, most females join the Arts and Humanities disciplines leaving the Science and Mathematics disciplines.

The low enrolment of Ghanaian female students in mathematics-related disciplines is significantly due to the number of factors that have been discussed such as societal beliefs and practices, gender stereotypes, unhealthy classroom environment, lack of role models, etc. (Boateng, 2015; Fletcher, 2009). On account of the patriarchal system deeply rooted

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in the Ghanaian society, females are made to believe at an early age that only males are good at mathematics (Boateng, 2015). Allotey (2012) opines that these societal beliefs have caused most females to view mathematics as a male domain and also as some "abstract black box" that contains nothing but complex, strictly held concepts and procedural imaginative formulae for memorization. By so doing, most Ghanaian females tend to lose confidence in mathematics and develop negative attitudes and anxiety towards mathematics (Asante, 2010; Mandina, et al., 2013).

Despite the educational and socio-cultural practices which undermine females' mathematics competence and efficacy right from infancy (Boateng & Gaulee, 2019; Hill et al., 2010; UNESCO, 2017), some women had been undeterred by these obstacles and had successfully obtained higher degrees in mathematics as well as retain in the mathematics profession. The study aims to probe into the experiences of successful female mathematics professionals in Ghana on what strategies they employed to climb higher the mathematical educational ladder and also overcome the gender stereotypes surrounding the subject. The study employed both qualitative and quantitation methods of data collection and analysis in order to wholly explore the life experience of female mathematics professionals who have been able to permeate the socio-cultural barriers and have retained in this androcentric field. The study attempts to give audience to successful female mathematics professionals to reflect on their own experiences, thinking, and actions. The researcher was also interested in finding out the elements that facilitated the resilience of these successful women and determine the support systems they ascribe to in pursuing mathematics as a career, thereby contributing to the alternative knowledge construction about women in mathematics.

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1.2 Statement of the Problem

Females remain underrepresented in mathematics-related programmes and careers (Fletcher, 2009; Yarkwah, 2020). This underrepresentation does not only contribute to the general shortage of mathematical scientists in Ghana, but it also influences performance for national development (Boateng & Gaulee, 2019). As research shows, gender diversity can contribute to creativity, productivity, innovation, and economical success of a country in various ways (Blackburn, 2017). Barriers such as socio-cultural beliefs and practices (Boateng & Gaulee, 2019; Mastercard 2018), parents' and teachers' gender-biased mathematics expectations (Boateng, 2015; Mandina, et al., 2013), and lack of role models (Fletcher, 2009; Mastercard 2018) are a few reasons outlined by literature why women leave mathematics fields. Hill et al., (2010) further posited that one main obstacle is the stereotypical belief that mathematics is a male domain, thus, the perception that women lack the innate ability to pursue mathematics. According to UNESCO (2017), the stereotypical belief has resulted in fewer females in mathematics at every level of education, with a high tendency of their participation decreasing as the level of education rises. Also, the stereotypic belief reflected in females' choice of a mathematical career as well (UNESCO, 2017).

In spite of the socio-cultural constraints that impede girls' mathematical ability and efficacy from childhood (Boateng & Gaulee, 2019; Hill et al., 2010; UNESCO, 2017), some women have persevered and pursued mathematics-related degrees and professions. However, not enough literature can be cited studying the experiences and impact of successful female mathematics professionals in Ghana, which will help establish a positive factor to bridge the gender gap, by motivating females in mathematics programmes and careers. Most of the literature (eg. Fletcher, 2009; Yarkwah, 2020) focused on Ghanaian female students' participation in mathematics in higher education,

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female attitudes towards learning and performance in mathematics and sex differences in mathematics performance (Asante, 2010). According to Hall and Suurtamm (2018) and Thoman et al. (2020), a lack of understanding of factors contributing to the success of female mathematics professionals across cultures, hampers the advancement of more women in mathematics fields, which in turn may influence the nation's development. As a consequence, the objective of this study is to inquire in depth and detail the life experiences of female mathematics professionals.

The study employed the resilience theory to identify the factors that have contributed to the success of females in mathematics fields and better understand how they overcame socio-cultural practices as well as some gender-biased educational practices. To help more women pursue mathematics in Ghana, there is the need to identify the successful female mathematics professionals whose profession has challenged the norm and practices. Additionally, the study aims at describing what these successful women did in order to learn mathematics and overcome the stereotypes surrounding the study of the subject, especially as women. It is hoped that in doing so, women who are dismayed would be informed and encouraged to do well in mathematics. Since mathematics is seen as the single element paramount to Ghana's economy (Anokye-Poku & Ampadu, 2020; Fletcher, 2009) there is the need to conduct this study.

1.3 Purpose of the Study

The purpose of the study was to investigate the life experiences of successful female mathematics professionals in selected tertiary institutions in Ghana.

1.4 Objectives of the Study

The study was guided by the following objectives:

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1. To investigate the life experiences of successful female mathematics professionals in their educational journey.
2. To find the elements that facilitated the resilience of successful female mathematics professionals in the field of mathematics.
3. To determine the support systems that influence the success of female mathematics professionals in the field of mathematics.
4. To find out the relationship between support systems and females' mathematical resilience

1.5 Research Questions

The following research questions guided the study:

1. What are the life experiences of successful female mathematics professionals in their educational journey?
2. What facilitated the resilience of successful female mathematics professionals in the field of mathematics?
3. What support systems influence the success of female mathematics professionals?
4. What is the relationship between support system and females' mathematical resilience

1.6 Research Hypothesis

In answering the fourth research question, the null hypothesis was formulated and tested as at 0.05 level of significance;

H_0: There is no statistically significant relationship between support system and resilience in mathematics.

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1.7 Significance of the Study

Exploring the experiences of successful female mathematics professionals during their educational journey provides an important framework to serve as a guide for future intervention in recruiting and retention of more females in mathematics-related programmes and careers. Also, the study of the experiences and successes of female mathematics professionals serves as a stepping stone for young girls who want to study mathematics. Thus, empowering and strengthening young girls who are dismayed that, they can also achieve their mathematical aspirations. The study reveals to female students the possible obstacles one is likely to encounter as a female in a patriarchal society vis a vis the study of a male-dominated discipline and as well provide the possible strategies one can employ to overcome such deterrents.

Furthermore, the findings of the study provide detailed information to the Girls Education Division of the Ghana Education Service, Ministry of Education (MoE), STEM clinics, schools, and parents on diverse support systems which can help facilitate the interest and resilience of females to pursue mathematics-related careers. The study also helps stakeholders identify the deterrents and negative experiences that have caused most females to restrain from the study of higher degrees in mathematics, hence the avenue to modify and create new policies which will foster and entice more females to pursue mathematics-related careers.

1.8 Delimitations

The study was narrowed to only female mathematics professionals who have pursued a 2nd degree and beyond in mathematics. It also focused on female mathematics professionals who were educated in any part of the globe. However, for accessibility, the researcher concentrated on female mathematics professionals in tertiary institutions in Central and Greater Accra region.

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1.9 Limitations

According to Terrel (2016), limitations are constraints outside of the control of the researcher and inherent to the actual study that could affect the generalizability of the results. In the study, the selection of the sample for the study was purposive and this have effect on the generalisability of the study. Also, a study of this kind should have covered a wider area since there are few female mathematics professionals in Ghana, but time constraints and limited financial resources became a limitation.

1.10 Definition of Terms

This section includes specific terms that the researcher explains in the context of the study.

Successful: A person who is pursuing or has a minimum qualification of a second degree in mathematics.

Successful female mathematics professional refers to any female who works or teaches in a mathematics-related career and is pursuing or has a minimum qualification of a second degree in mathematics related field.

Resiliency: the dynamic process whereby individuals achieve success despite the obstacles that prevent the majority of others from the same background from succeeding (Morales & Trotman, 2004).

1.11 The Organization of the Study

The study is structured into five chapters. Chapter 1 presented a background to the study, statement of the study problem, purpose of the study, objectives of the study, research questions, significance of the study, delimitations of the study, limitation of the study, definition of terms, and organization of the study. Chapter 2 reviewed some relevant literature for the study and discussed the theoretical framework guiding the study. Chapter 3 described the research methodology which includes the research design, the

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population and sampling techniques, research instrument, pilot study, validity and reliability of the instrument, procedures used for data collection, data analysis, and ethical issues. The demographic characteristics of the respondents, results and the findings of the analysed data were identified, interpreted and discussed in Chapter 4. Chapter 5 comprised of summary of key findings, conclusions, recommendations, and areas for further research.

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CHAPTER 2

LITERATURE REVIEW

2.0 Overview

This chapter basically focused on diverse views on what other authors have written concerning the topic under study. The literature review was discussed under the following themes:

- Theoretical Framework
- Experience of African Women in Higher Education
- Experiences of Women in STEM Globally
- Statistics of Females Participation in Mathematics Higher Education in Ghana
- Experiences of Ghanaian Women in STEM (Mathematics and Science) Education
- Factors That Facilitated Resilience of Females in Male-Dominated Fields
- Support Systems That Influence Success of Females in Male-Dominated Disciplines

2.1 Theoretical Framework

The theories behind the study were based on Mathematical Resilience and Self-efficacy.

2.1.1 Resilience Theory

The construct of mathematical resilience stems from the concept of psychological resilience. The roots of resilience theory began in the 1980's and 1990's with Werner and Smith's paper, "Risk, Resilience, and Recovery: Perspectives from the Kauai Longitudinal Study," which focused on children who had learned to lead successful lives despite environmental hardships and extreme stresses during their upbringing (Werner, 1993; Werner & Smith, 1992). Subsequently, during the last two decades of the 20th-century researchers adopted the concept of Resiliency into the Social and Educational

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sphere (Cassidy, 2016; Morales & Trotman, 2004; Tudor & Spray, 2017; Ungar, et al., 2008). With reference to the studies of Yeager and Dweck (2012) resilience is any behavioural, attributional, or emotional response to an academic or social challenge that is positive or beneficial for development. Abiola and Udofia (2011) associated resilience with increased quality of life, well-being, and functional capacity in times of adversity. Despite the instinctive appreciation for the "meaning" of resilience and what it infers (about the individual), the consensus in defining resilience, both conceptually and operationally as a measurable construct has yet to be reached. Friedland (2005) opined that there are diverse perspectives and elusive concepts on the definitions of resilience. In an attempt to give a detailed explanation of the concept, Gilligan (2001) used the example of a resilient person as an individual who does better than they ought to, considering what has happened to them. The range of available definitions reflects resilience in its depth and breadth which indicates that resilience is both multi-faceted and multi-levelled. This means that resilience may vary across contexts and over time (Tudor & Spray, 2017). Pooley and Cohen (2010) describe resilience as "the potential to exhibit resourcefulness by using internal and external resources in response to different contextual and developmental challenges...." (p.34). Moreover, Hamill (2003) and Gilligan (2001) in their studies described resilience as a set of qualities or the competence to withstand adversities and challenges within a specific context.

2.1.1.1 Educational Resilience

In general, resilience is based on two core elements: adversity and positive adaptation (Windle, 2011). Correspondingly, in the educational context, academic resilience is defined as the successful educational attainment of a student despite obstacles that prevent majority of the other students from the same background from succeeding (Cassidy, 2016). According to Hutauruk and Priatna (2017), academic resilience is

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associated with a student's affective ability to deal with and be able to overcome obstacles and negative situations encountered during the learning process, transforming those negative situations into situations that support them. Tudor and Spray (2017) emphasized that resilient students are those who maintain high motivational achievement and performance even when faced with stressful events and conditions that place them at risk of failure. For instance, relative to the study, the inspiration and motivation for a Ghanaian female to attain higher degrees in a male-dominated field (like mathematics) whiles being surrounded by socio-cultural beliefs and practices. In other words, academic resilience represents a state, in which the student (from a minority group) achieves much higher educational goals than the common average (output) of other students (Morales & Trotman, 2004). In relation to females' educational resilience, Martin (2013) and Buse et al. (2013) described academic resilience as the capacity or tenacity to overcome significant adversity (such as gender stereotypes, lack of role models and inappropriate instructional methods of teaching) that threatens female student's educational achievement.

With the aim of giving a deeper understanding of the process of academic resilience, Cassidy (2016) identified three significant factors in a study on "The academic resilience scale". Findings from Cassidy's (2016) work identified the first factor of academic resilience to be perseverance, which includes hard work and trying not to give up, sticking to plans and goals, accepting and utilizing feedback, imaginative problem solving, and treating adversity as an opportunity to meet challenges and improve. The second factor reflected adaptive help-seeking, which included reflecting on strengths and weaknesses, altering approaches to study, seeking help, support, and encouragement, monitoring effort and achievements, and administering rewards and punishments. The last factor was negative affective and emotional response, which included anxiety,

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catastrophizing, and avoiding negative emotional responses. Indeed, the three factors of academic resilience are extremely important to this study, because they create the avenue for female students in male-dominated fields to learn specific behaviours and actions that cultivate greater goal orientation towards mathematical achievement and improve positive academic adaptation (protective factors).

2.1.1.2 Resilience in Mathematics

Numerous models have been developed to describe resilience in the academic domain (Ishak et al., 2020). Some researches (Cassidy 2016; Morales & Trotman, 2004; Tudor & Spray, 2017) focused on the entire educational life path, while others (Chirkina et al., 2020; Kooken et al., 2013; Thoman et al., 2020) concentrate on specific subjects (such as mathematics, science etc). Focusing on mathematics as a subject of study, most scholars (Arastaman, & Balci, 2013; Chirkina et al., 2020; Johnston-Wilder & Lee, 2010; Hutauruk & Priatna, 2017) have demonstrated that resilience is one of the factors for a student's success in mathematics. The concept of studying resilience in mathematics is known as mathematical resilience (Johnston-Wilder & Lee 2010; Ishak et al., 2020). Since 2008, researchers (Arastaman, & Balci, 2013; Johnston-Wilder & Lee, 2010; Kooken et al., 2013) have produce papers to discuss mathematical resilience. According to Goodall and Johnston-Wilder (2015), Mathematical Resilience is a positive stance towards mathematics that enables students to develop approaches to mathematical learning which aids them to overcome the barriers and setbacks that can be part of learning mathematics for many people. Kooken et al. (2013) also asserted that the quality by which some learners approach mathematics with confidence, persistence and a willingness to discuss, reflect and research is referred to as mathematical resilience. Generally, mathematical resilience focuses on encouraging engagement and persistence in mathematics in a way that reduces the negative effects of anxiety in mathematics

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(Hutauruk & Priatna, 2017). According to Johnston-Wilder and Lee (2010), students who have mathematical resilience will persevere when faced with difficulties, will work collaboratively with their peers, will have the language skills needed to express their understandings and will have a growth theory of learning, that is they will know that the more they work at mathematics the more successful they will be. Goodall and Johnston-Wilder (2015) opines that the ability of students to engage with mathematics, struggle through problems, deal with barriers and misunderstandings and work on mathematical ideas best describes their resilience in mathematics.

In explaining the multidimensions of mathematical resilience Johnston-Wilder and Lee, (2010) and Kooken et al., (2013) cited the following as three correlated factors in constructing the ability of mathematical resilience:

Value: it refers to the extent to which students find studying mathematics important in attaining their current or future goals, and is an established precursor to success. This means that the perception that mathematics is a subject that is valuable and worth studying. The more the students think mathematics is valuable, the greater their motivation to learn and to cope with the difficulties that arise when studying it. In addition, the extent to which a student perceives mathematics to be valuable is believed to positively correlate with their level of motivation to study it. If a student greatly values either studying mathematics or careers that require mathematics, they are more persistent even in the face of challenge.

Struggle: This refers to a student's belief that they sometimes have to exert a great deal of effort because mathematics can be a challenge to learn, but their difficulty is not interpreted as an indication of personal incompetence. In other words, the experience of struggling with mathematics is not unusual; even exceptional mathematicians have to

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work hard and even make errors when learning and solving mathematics problems. The instrument focuses on Struggle in reference to student perceptions and tolerance of the level of difficulty in studying mathematics. When a student believes that Struggle is inherent to the study of mathematics, they attribute the reason for the challenge to aspects related to the mathematics rather than on limitations in their ability.

Growth: the growth theory of learning mathematics refers to the belief that the level of knowledge of mathematics is a malleable attribute that can grow. Yeager and Dweck (2012) in their study on Implicit theories of intelligence reported that students with a growth theory of intelligence believe that if they work at it, they can learn more. However, students with a fixed theory believe that their level of intellect is static, and they are limited in developing this fixed ability level. Yeager and Dweck (2012) further added that when it comes to learning of mathematics, resilient students have a growth mindset. They are at ease with difficulty and the concept of mathematical struggle. Also, resilient students realize when they are stuck and know how to seek assistance when they need it. Most importantly, they believe they are capable of doing mathematics.

2.1.1.3 Protective Factors

Researchers (Benard, 2004; Morales & Trotman, 2004) have discovered that individuals overcome adversities and challenges by utilizing protective factors. According to Rutter (2012), protective factors are individual traits and external characteristics that work as dynamic mechanisms to help individuals resist the challenge to which they are exposed. Within the educational context, Tudor and Spray (2017) described protective factors as factors that buffer against the adverse effects caused by the obstacle to produce academically successful students. Cassidy (2016) and Tudor and Spray (2017) in their

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studies identified the following as common protective factors associated with educational resilience:

- self-efficacy,
- self-motivation,
- independence,
- effective coping skills
- parental support
- school support
- social support (peers, community, etc)

For better comprehension of the common protective factors identified by Cassidy (2016) and Tudor and Spray (2017), Benard (2004) classified the protective factors into two categories: internal and external protective factors.

Internal protective factors: Recent studies have revealed that internal protective factors are individual qualities and characteristics (skills, attitudes, beliefs, and values) associated with positive developmental outcomes (Benard, 2004; Cassidy, 2016; Morales & Trotman, 2004). Tudor and Spray, (2017) elucidated that internal protective factor includes high self-efficacy, self-awareness, strong problem-solving skills, and well-defined goals and aspirations, which develop both naturally and in response to environmental protective factors, and they contribute to the positive academic outcome. In addition, Arastaman, and Balci (2013) opined that when students are nurtured in a quality environment, encouraged and allowed to develop their own basic human needs; it promotes individual resilience strengths.

External protective factors: In a survey of resilience research, Benard (2004) outlined three external protective factors: caring relationships, high expectations, and meaningful

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ways to participate in activities. Benard (2004) applied the external protective factors to three areas: families, schools, and communities. Such avenues serve as places of support where individuals receive support related to their developmental needs of safety, love and belonging as well as their adversities and challenges (Benard, 2004). In addition, Brown et al. (2001) postulate that external protective factors are characteristics that enable students to be resilient through utilizing them as strongholds. Also, connections with family and environment are the main source of assistance that facilitates resilience for at-risk students and acts as a medium for thriving development (Brown et al., 2001). In the educational sphere, Martin (2013) opined that the school as a protective factor fosters academic resilience in females by promoting a good teacher-student relationship, motivating the attainment of realistic and aspiring goals in female students as well as nurturing female students' abilities and potentials.

Furthermore, Morales (2000) discovered that the relationships created with internal and external protective factors positively influenced academic success. As such, Morales (2000) established the five steps resilience cycle model; a process found in resilient students. The five steps of the resilience cycle recognize the agency of the resilient student to be aware of the challenges, identify protective factors that help mitigate their specific challenges and employ continued active maintenance of the protective factors. Morales (2000) five steps resilience cycle are as follows:

- the students realistically and effectively identify their challenges.
- the student is able to manifest protective factors that have the potential to mitigate the potentially negative effects of the perceived challenge.
- the protective factors work in concert to propel the student toward high academic achievement and success.

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- the student is able to recognize the value of the protective factors, and continually refines and implements them.
- the consistent and continuous refinement and implementation of protective factors, along with the evolving vision of the student's desired destination, sustain the student's academic achievement as new academic challenges present themselves.

2.1.2 Self-Efficacy Theory

Self-efficacy is one of the main underpins of academic resilience (Martin, 2013) and it is commonly defined as students' belief about their capabilities to achieve a goal or a positive outcome (Bandura et al., 2001). Bandura (1977) described self-efficacy as the personal expectation or judgment concerning one's competence to accomplish a specific task. According to Bandura et al. (2001), self-efficacy beliefs form the foundation of human agency. This means that, unless individuals believe that they can produce the desired results by their actions, they will have little incentive to act or to persevere in the face of challenges. Like resilience, self-efficacy is also context-specific and it is particularly important when individuals face obstacles (Bandura, 1999). According to Hamill (2003) and Cassidy (2015), the self-efficacy theory in relation to academic resilience can simply be explained as students' belief of their capabilities needed for the organization and execution of a task in order to achieve academic success. When positive self-efficacy beliefs are associated with perseverance and motivation (Bandura et al., 2001) there is an increased likelihood of rejecting negative thoughts regarding one's academic capabilities (Sawtelle et al., 2012). In relation to female students' self-efficacy belief, Kolbe (2009) found that female students who demonstrate a strong sense of self-efficacy mostly take-up tasks that are challenging and are intrinsically motivated. Maddux (2013) opined that female students with high self-efficacy belief do not become victims of academic setbacks, rather, they recover quickly and achieve their personal

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academic goals. On the other hand, female students with low self-efficacy belief make no initiative for self-determination (Maddux, 2013). William (2019) asserted that since female students with low self-efficacy are less determined, they mostly consider challenging programmes (such as mathematics and science) as threats needed to be avoided instead of opportunities. Similarly, Maddux (2013) emphasized that female students with low self-efficacy are pessimist with little academic aspiration which mostly result in disappointing academic achievement as part of their self-fulfilling feedback.

In an analysis to determine female students' profiles according to academic resilience, Hamill (2003) revealed that resilient female students demonstrated a strong sense of self-efficacy, persistence and planning and were low in anxiety. Hamill (2003) further asserted that female students' level of self-efficacy is a salient predictor that distinguished resilient and non-resilient students. A vivid explanation of the sources for the development of self-efficacy beliefs (Bandura, 1999) in relation to female mathematical achievements and resilience with the work of Zeldin and Pajares (2000) in perspective are as follows:

Mastery experience: It is regarded as the most important source of self-efficacy information for females because it provides evidence and interprets results of past mathematics performance of female students. The authentic mastery experience of female students' performance on a given mathematical task creates a strong sense of efficacy in completing similar tasks in the future. Alternatively, repeated failure in a given mathematics task lowers female students' efficacy perceptions, particularly when such failures occur in their early years of schooling and it cannot be attributed to lack of effort or external circumstances. Continued success, on the other hand, instils in female students' strong mathematical efficacy beliefs that are unlikely to be undermined by occasional failures.

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Vicarious experience: it is also an influential source of self-efficacy information for female students when they observe other people successfully perform a mathematical task or attain a mathematics career. Observing the successes and failures of others who are perceived to have similar abilities enables female students to believe in their own abilities. The presence of role models in mathematics is particularly essential for enhancing female students' mathematical self-efficacy (Valk et al., 2014) When female students are exposed to role models, they form the right judgement of their mathematical competence. Parents, older siblings, teachers, and mathematics professionals can all serve as role models for female students. A study conducted by Sawtelle et al. (2012) highlighted that, female students relied primarily on the vicarious experience source for evaluation of self-efficacy in mathematics and science disciplines. Williams (2019) also asserted that resilient females consistently reported experiences that involved an influential person who helped them develop their beliefs about their mathematical capabilities.

Verbal persuasions: influential people in the lives of female students such as parents, teachers, peers, and counsellors strengthen the efficacy beliefs of females in mathematics through positive feedback. Verbal messages and social encouragement help female students to exert the extra effort and maintain the persistence required to succeed in the study of mathematics; it also results in the development of skills and personal efficacy. According to Mau (2003) verbally convincing female students that they are indeed capable of accomplishing a particular mathematics task has the greatest effect on those who already believe they are capable. Besides, negative messages can also undermine efficacy beliefs when used to compel female students that they lack capabilities. For example, findings from Mau (2003) revealed that when female students received social messages that they do not belong in a male-dominated field such as mathematics and

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science, they became vulnerable to believing that they are not, and cannot be, competent in that area. Mau (2003) concluded that female students were attentive and susceptible to the encouragement of those about whom they cared and with whom they felt a relational bond.

Physical and Emotional state. This source of self-efficacy information allows female students to assess their confidence in completing a mathematical task based on their level of physical and mental stressors. Stress reactions are often interpreted as signs of vulnerability to poor performance whereas positive emotions can boost confidence in one's skills. For instance, most female students' mathematics anxiety undermines their confidence and mathematical efficacy (Asante, 2010). However, Bandura, (1977) argued that what matters is not the intensity of emotional and physical reactions but how they are perceived and interpreted. People who have a high sense of efficacy are more likely to view their state of affective arousal as an energizing facilitator of performance, whereas those who are beset by self-doubts regard their arousal as a debilitating factor (Bandura, 1977).

2.2 Experience of African Women in Higher Education

Higher education is an indispensable element for the building of the human capacity of a nation and its socio-economic development (Atuahene & Owusu-Ansah, 2013). The importance of higher education is well articulated in both international and national policy documents (Morley et al., 2010; Singh, 2001). Singh (2001) for example calls this the private and public good of higher education, which means that the knowledge and skills participants obtain in higher education enable them to be able to manage and transform national economies and also improve the social lives of citizens. In addition, Bloom et al. (2014) posited that higher education creates greater tax revenue, increases savings and investment, and leads to a more entrepreneurial and civic society. Higher

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education improves a nation's health, contributes to reduced population growth, improves technology, and strengthens governance. (Bloom et al., 2014). Research has shown that countries with gender parity in higher education have experienced an immense improvement in their development (UNESCO, 2012)

Drawing from Assié-Lumumba (2006), the gender-based disparity in higher education is one of the areas that differentiate economically advanced countries from developing countries. UNESCO (2012) opined that, women are approximately half of the world's population, and also have a huge influence on the well-being of their families and societies, hence the need for gender parity in all levels of education. UNESCO's (2012) opinion is consistent with the assertion of Dr Kwegyir Aggrey (a Ghanaian scholar and educator) "If you educate a man, you educate an individual but if you educate a woman, you educate the whole nation" (Ephson, 1969 cited in Adu-Yeboah, 2011, p. 9). Hannum and Buchmann (2005) also posited that when women gain access to higher education in a country, economic productivity rises, maternal and infant mortality rates fall, fertility rates decline, and the health and educational prospects of the next generation are improved. It is therefore expedient that gender parity must be attained at all levels of education (Mukhwana et al., 2020; UNESCO, 2017).

Despite the numerous advantages of gender parity in higher education some African countries marginalize and disfavour women in higher education (UNESCO, 2009). Education statistics in Sub-Sahara African (SSA) countries show that women continue to lag behind men in education in general and specifically in science, mathematics, and technology education (Masanja, 2010). UNESCO (2009) report on "Comparing Education Statistics Across the World" shows that in sub-Saharan Africa, the tertiary GER (Gross Enrolment Ratio) for men is 6.8%, which is 1.5 times as high as that for women (4.5%). This means that for every 100 male students enrolled in 2007, there are

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only 66 female students. Researchers (Adusah- Karikari, 2008; Morley et al., 2010; Morley et al., 2009) highlighted colonial impact, low socioeconomic background and cultural impediments as few factors which have had influence on the educational experiences of women in higher education from SSA countries like Uganda, Tanzania and Ghana.

One often-cited factor associated with the educational experiences of African women in higher education is the misguided colonial educational policy, which did not have specific place for women in higher education (Atuahene & Owusu-Ansah, 2013). Historically, the colonial higher education model for which Africa traces its modern universi¬ties was primarily designed to educate males who will pro¬vide administrative assistance to the colonial government, thus universities did not have any voice or important place for women (Assié-Lumumba, 2006; Mama, 2003). The practice did not change during the immediate years after independence as most first and second-generation African leaders did not proactively make plans to improve women's participation in higher education, thereby perpetuating the long-standing inequity (Agyepong, 2001; Atuahene & Owusu-Ansah, 2013). As Mama (2003) argued, "African governments have not formally excluded women from participation in higher education, as the colonial policies did, but they have tended to treat the attainment of nation-statehood as a collective restoration of conventional masculinity which has precluded full and equal participation of women in the national project." (p. 102). In affirming the impact of colonization on African women in higher education, Aidoo (1995) as cited in Adusah-Karikari (2008) reported that most women were not equipped educationally and technically to play prominent roles in Ghana's industrialization process. Generally, women in Africa under the colonial rule entered academia later than their male counterparts (Tamale & Olako-Onyango 2000). Staudt 1981 as cited in Adusah-Karikari

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(2008) attested to the fact that not only did missionary education disproportionately extend educational opportunities to males but men's education was also accorded higher priority than that of women. Even when women gain access to higher education, the aim of the missionaries was to groom young women to become fit wives for the men (Adusah-Karikari, 2008). An educated housewife was viewed by the colonials as a potential person who would motivate her husband's productivity (Bartels 1965 as cited in Adusah-Karikari, 2008; Tamale and Olako-Onyango, 2000). In addition, Tamale and Olako-Onyango (2000) reveal that the 1935 commission on Higher Education in East Africa, emphasized women's restricted educational experiences by advocating for their education in only hygiene, domestic management, nursing, and midwifery. Consequently, this approach resulted in limited access for women to STEM programs. Boateng (2015) opined that this is a clear indication of a deliberate attitude to prevent women from contributing their quota to the African STEM academic society.

In summary, experience of African Women in Higher education includes Historical biases from colonial education, Post-independence exclusion of women and Limited access, especially in STEM fields,

2.3 African Socio-Cultural Practices and Expectations

The discussion of female experience in higher education in Africa cannot be completed without locating it within the context of culture and gender roles. Culture is the totality of the way of life evolved by people through experience and reflection in an attempt to fashion a harmonious co-existence with their environment. (National Commission on Culture [NCC], 2004). NCC (2004) emphasizes the need for the individuals to preserve and use their cultural heritage and resources to develop a united national community with a distinctive identity, collective confidence and pride of place among the community of nations. According to Geert (2011), culture is deeply rooted and embedded in every

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society and it is keenly passed down from generation to generation. Focusing on the African society, Kuenyehia (1995) revealed that life in Africa is organized around an unwritten social contract; that is a gender construct in which women assume the reproductive role while men are ascribed the primary responsibility for the family's economic growth. It can easily be seen that males and females are differentiated not only by their biological sex, but also by behaviour, the clothes they wear, their access to higher education and the kind of jobs and activities they engage in. Biklen and Pollard (1993) asserted that being male or female carries few meanings in and of itself; its most potent meanings come from social and cultural meanings attributed to it. As such, the World Health Organization (2010), referred to gender as the array of socially constructed roles, personality traits, attitudes, behaviours, and influence that society ascribes to males and females.

Moser (2003) asserted that the gender-based socio-cultural practices and expectations have had a significant impact on the way women experience higher education. These norms and expectations exert a substantial influence on women's access to, participation in, and overall experience through the sphere of higher education. Research highlighted three prominent and well-known gender-based socio-cultural practices for women in the African society as reproductive, productive and community management (Moser 2003). This means that, the society stresses on motherhood, marriage and participation in communal labour as the primary goal in life for women, a goal that is deeply ingrained by the time they reach adulthood. According to Adu-Yeboah (2011), most socio-cultural practices pressure women to start a family ahead of their profession and pursuit of higher educational degrees. Morley et al. (2009) also opined that the unwritten social construct of the well-articulated socio-cultural gender roles negatively influence women's possibility of access and participation in higher education. According to Atuahene and

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Owusu-Ansah (2013), in most African societies, when the family budget is tight, there is an entrenched perception of parents sacrificing their daughters' higher education and request of them to participate in economic activities to supplement household income. Females are more likely than males to support their family either by engaging in selling goods and services or babysitting their younger siblings, at the expense of their education (Adu-Yeboah, 2011; Atuahene & Owusu-Ansah, 2013). Daddieh (2003) emphasized that most socio-cultural practices have devalued the educational achievements of females, and thereby undermine their participation in higher education. Although the negative cultural perceptions about the value of women's education is gradually fading away in some African societies, some culturally endemic areas continue to perpetuate binary gender roles which have reduced women to household chores; a notion perceived traditionally as the proper role and place of women in society instead of educational advancement (Acheampong, 2014; Adu-Yeboah, 2011).

In summary, women's experiences in African higher education are closely linked to cultural and gender norms. These norms often prioritize women's roles in reproduction, household work, and community labour, pressuring them to start families before pursuing higher education. Cultural biases devalue women's educational achievements in some areas, limiting their opportunities for academic advancement. While progress is being made in challenging these norms in some African communities, traditional gender roles persist, restricting women to domestic roles rather than educational and professional pursuits.

2.4 Experiences of Women in STEM Globally

"Twenty years after, we are not there yet," declared Irina Bokova (Director-General of UNESCO) in her speech on Women and Girls in Science, Technology, Engineering and Mathematics: Progress and Challenges (UNESCO, 2015, p.1). UNESCO (2015)

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highlighted three persisting gaps in STEM: a disparity in the number of young girls and women participating in STEM, a lack of relevant data to fully understand the realities influencing women's participation in the STEM field and an absence of effective and targeted policies to resolve the issue. Moreover, the World Economic Forum Report (2016) indicated that women continue to remain underrepresented among STEM graduates for which the global gender gap stands at 47 percent, with 30 percent of all male students graduating from STEM subjects, in contrast to 16% of all female students. The World Economic Forum Report (2016) highlighted that females mostly experience stereotype threats which have been noted to lower girls' performance and aspirations vis-à-vis their science and mathematics studies.

According to Shapiro and Williams (2012), understanding the phenomenon of stereotype threat will help understand how such deterrents undermine females' performance and interest in STEM domains, even when females' have positive mathematics attitudes. The concern that others will view one stereotypically (Spencer et al., 1999), has been identified by researchers (e.g., Gunderson et al., 2012; Hall, 2012) to account for the gender differences in mathematics. Research has shown that females experience stereotype threats throughout their years of schooling in the mathematics class, which negatively impacts their participation in mathematics related professions (Hill et al., 2010). In other words, stereotype threat is the main underlying theory of the loss of girls' and women's performance and interest in STEM disciplines (Shapiro & Williams, 2012). Marchand and Taasoobshirazi, (2013) explained stereotype threat as the fear of confirming a negative stereotype about oneself, because of one's association with a stereotyped or marginalized group (e.g., women in mathematics). As asserted by Shapiro and Williams (2012), negative stereotype destabilizes and dislocates female students' attitudes toward pursuing goals in STEM. According to Gunderson et al. (2012) female

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students often experience stereotype threat, which increases anxiety and robs them of their cognitive resources, ultimately leading to a deteriorated performance in mathematics. For instance, Spencer et al. (1999) in one of their earliest experiments demonstrated how females underperform when they experience stereotype threats. They recruited 30 females and 24 male first-year students with similar mathematics abilities as measured by grades and test scores and divided them into two groups. Half of the participants were told that the mathematics test is difficult and men perform better than women (threat condition) and the other half were also told that the mathematics test is gender-fair and does not show gender differences (non-threat condition). The study revealed that females performed significantly worse than males in the threat condition, however, the gender difference almost disappeared in the non-threat condition. Affirming the findings of Spencer et al. (1999), Nosek et al. (2009) conducted an implicit association test with 34 countries to ascertain the influence of nation-level implicit gender stereotypes on eighth-grade science and mathematics achievement. Nosek et al. (2009) study revealed that implicit stereotypes and gender differences in science and mathematics participation and performance are mutually reinforcing, contributing to the persistent gender gap in science and mathematics engagement.

2.6.1 Biological Differences

A wide range of researchers have attributed the underrepresentation of females in mathematics and science to biological factors; hormonal, neurological, and cognitive (Ceci et al., 2009; Halpern, 2000). In January 2005, Lawrence Summers, who was the then-president of Harvard University, in his address at the National Bureau of Economic Research Conference opined that one reason why women are underrepresented in science and mathematics careers could be “innate differences” between women and men (Bombardieri, 2005). An uproar was sparked because of the use of the word, “innate,”

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which means "inborn" or "not caused by experience." Apart from Summer (Bombardieri, 2005), Halpern (2000) also contended that males' brains have neurological qualities that make it possible for them to perform better in mathematics than females. Halpern (2000) further went on to utilize Geschwind's (1983) theory of prenatal hormonal effects to explain the "biological difference between males and females in mathematics. Halpern (2000) believes that "the higher levels of prenatal testosterone in males would result in the greatest level of right-brain dominance, with which males would develop cognitive ability patterns that were more closely associated with right hemisphere functioning. Thus, since both mathematical reasoning and spatial abilities are under greater control by the right hemisphere, males will perform better on mathematical reasoning and spatial tasks than females." (p.153)

In affirmation of the assertion of Summer (Bombardieri, 2005) and Halpern (2000), Henrion (1997) observed that "in the mathematics community, there is a common belief that being a woman and being a mathematician are incompatible." (p. xxiv). Thus, one can either be a woman or a mathematician, but not both because their hormones are not compatible with mathematical development. On the other hand, concerted efforts have been made by some scholars (Hill et al., 2010; Reilly et al., 2017; Wang et al., 2013) to debunk the biological arguments that females brain develops differently from males and thus has resulted in the underrepresentation of females in science and mathematics, most especially on spatial abilities. Spatial ability lays the foundation for quantitative reasoning, a collective term for mathematical and science skills (Reilly et al., 2017). Generally, spatial skills are not innate but can be developed in a short time with simple training, hence there is no "smarter sex" (Hill et al., 2010). A study conducted by Reilly et al., (2017) on gender differences in spatial ability reveals that, like other cognitive skills, instructions and practice can yield dramatic improvements in performance on

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spatial tasks, reducing the magnitude of gender differences. In addition, Sorby and Baartmans (2000) conducted research on the development and assessment of a course for enhancing the 3-D spatial visualization skills of first-year engineering students. The study posited that, if females grow up in an environment that enhances their success in science and mathematics with spatial skills training, they are more likely to develop their skills as well as their confidence and consider a future in science and mathematics disciplines. Moreover, a growing number of educational psychologists (e.g., Halpern et al., 2007; Hill et al., 2010; Reilly et al., 2017) have argued that early education of spatial intelligence is necessary as a matter of equity for all students and that it may offer substantial benefits for the later development of mathematical and scientific skills across all ability levels. To complement the argument that there is no biological difference between males and females, research has shown that in some gender-equality countries females outperform males to a significant degree in mathematics and science (Guiso et al., 2008; Reilly, 2012).

2.6.2 Gender Differences in Attitudes towards the Study of Mathematics

According to Mensah et al. (2013), attitudes toward mathematics signify a belief that one is good or bad at mathematics, a tendency to engage in or avoid mathematical activities, and a belief that mathematics is useful or useless. Riegle-Crumb et al. (2011) also described attitudes toward mathematics as the positive or negative emotional disposition towards mathematics. Globally, several scholars (e.g., Asante, 2010; Charles et al., 2014; Teye-Nartey, 2018) have found a significant difference in attitudes between genders towards the study of mathematics. And this remarkable difference is in favour of the boys (Asante, 2010). A study conducted by Gunderson et al. (2012) discovered a high rate of negative attitudes and anxieties towards the study of mathematics among female students in the United States of America. Even though Hill et al. (2010) found an equal aptitude

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and innate abilities between males and females, most girls fear Mathematics (Asante, 2010). The fear of mathematics among female students stems from what Lim (2002) as cited in Haylock and Manning (2014) described as the three myths of mathematics which states that mathematics is a difficult subject, a subject for males and the clever ones. In addition, Teye-Nartey (2018) study in Ghana also revealed that most female students exhibit low confidence in mathematics, had traumatizing causal attribution patterns, perceived mathematics as difficult, and were also anxious about mathematics. According to Hill et al. (2010), female students' negative attitudes towards mathematics mostly develop during elementary school and persist through secondary and tertiary education. Ekine et al. (2013) also asserted that female students' inherent phobia and susceptible attrition in mathematics-related careers is as a result of their negative attitude towards mathematics throughout all levels of education. The negative attitudes and waning interest of female students toward mathematics have caused many female students to have a nerd for programmes such as arts and humanities which they perceived to be more relevant than mathematics and science programmes (Ekine et al., 2013). With a myopic view of the relevance of mathematics, Kiptum et al. (2013) opined that most female students view mathematics as a rule-oriented, less rewarding and a must be obeyed subject; hence their negative attitude towards mathematics. Moreover, Asante (2010) argues that the type of attitude held by a female student towards mathematics is mostly enacted by the ancient and erroneous stereotype belief that males are better equipped to tackle scientific and mathematical tasks. The beliefs and perceptions of the society about mathematics have greatly contributed to the attitude of female students toward the study of the subject (Asante, 2010; Hill et al., 2010).

Contrary to the findings of Gunderson et al. (2012) and Teye-Nartey (2018) which revealed the negative attitude of female students toward the study of mathematics,

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Mohamed and Waheed (2011) discovered a positive attitude of female students toward mathematics. Yarkwa (2020) asserted that most female students discard the perception that mathematics is a male domain and a difficult subject. In addition, findings from Asare-Nkoom's (2007) and Anokye-Poku and Ampadu (2020) established that there is no significant difference between the attitude of male and female students toward the study of mathematics. Thus, both male and female students exhibit positive attitudes toward mathematics and attribute the knowledge gained in learning mathematics as a useful resource to solve real-life problems (Anokye-Poku & Ampadu, 2020). According to the findings of Charles et al. (2014) countries with gender equality have no remarkable difference in attitudes between males and females.

2.5 Statistics of Females Participation in Mathematics Higher Education in Ghana

In Ghana, higher education has experienced an eminent growth relating to accessibility and participation (National Accreditation Board, 2012-2018). According to Atuahene and Owusu-Ansah (2013), within 18 years, university education enrolment increased from below 9,997 in 1992 to more than 132,000 in 2010, representing an increase of 1,220% (12-fold). Atuahene and Owusu-Ansah (2013) further revealed that female enrolment has seen a significant degree of improvement with a Gross Enrolment Ratio (GER) of 1.52% in 1999 to 9.24% in 2011 whilst male enrolment increased from 4.28% to 14.92%. Ghana has clearly made significant progress toward increasing access to higher education of female, yet, these developments have not trickled down to females' choice of programmes of study. Yarkwa (2020) asserted that the participation of women in mathematics has been and is still low in Ghana.

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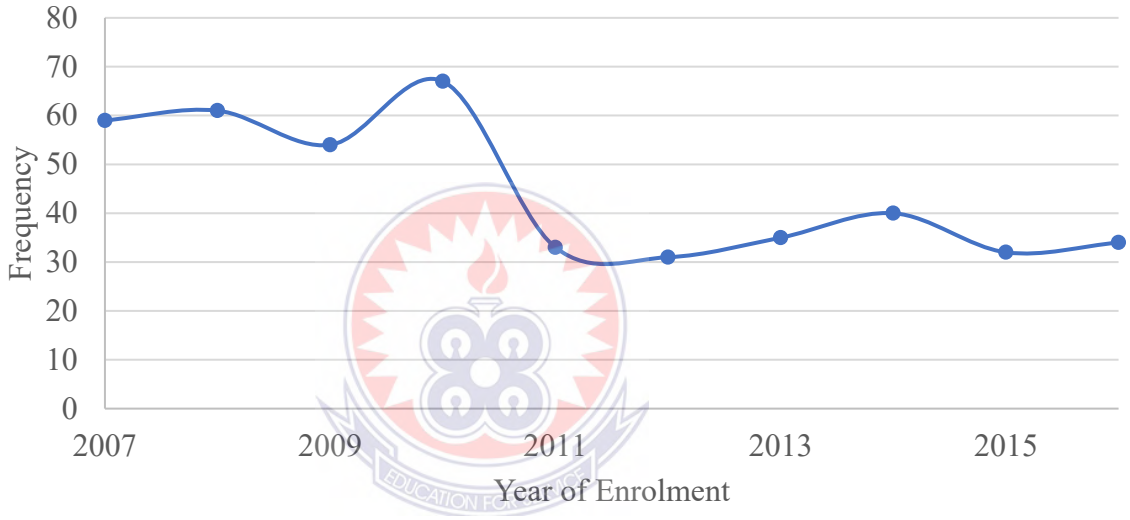
An analysis of the enrolment trend of females in mathematics in two Ghanaian public universities (Yarkwah, 2020) revealed that, for the past decade females' enrolment in mathematics at the high level of education has been on a decline (see Figure 1)

Figure 1.

Frequency polygon illustrating the enrolment trend of females in mathematics from 2007 - 2016



With reference to Figure 1, it can be seen that the participation of female students in mathematics education was higher from 2007 to 2008, followed by a declined from 2008 to 2009. From 2009 to 2010, there was a rise in the enrolment of females into mathematics education. However, the curve showed a steep decline in enrolment from 2010 to 2011. Moreover from 2011 to 2014 the enrolment increased at a low rate, followed by a decline from 2014 to 2015 and then a rise from 2015 to 2016. Considering the last 5 years, enrolments of female students in mathematics education from 2011 to 2016 were lower as compared to the enrolment of female students in mathematics

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education from 2007 to 2010. This is a clear indication that in recent years, female students' participation in mathematics education has been on a decline.

Yarkwa (2020) asserted that the low enrolment of females in mathematics could stem from the fact that females are less likely to select a mathematics-related programme as a programme of study. Fletcher (2009) argued that the underrepresentation of females in mathematics at the higher level is a carry-over effect from the participation of females in senior secondary school elective mathematics, a subject which is a prerequisite for studying mathematics-related programmes at the degree level. Baah-Korang et al. (2015) in their study on gender differences in participation in elective mathematics in Senior High Schools in Ghana reveal that the statistics of males' and females' participation in elective mathematics are 50.5% and 27.2% respectively. In addition, UNESCO (2017) discovered that females drop out much earlier at secondary school as they approach advanced STEM education, hence resulting in their underrepresentation in STEM-related programmes and careers.

2.6 Experiences of females in STEM (Mathematics and Science) in Ghana

STEM underpins the 2030 Agenda for Sustainable Development and the Africa Union 2063 Agenda (UNESCO, 2017). The Sustainable Development Goals (SDG) highlighted the importance of STEM fields for a more peaceful and prosperous world, as well as gender equality in terms of ensuring equal access to STEM education for women and men alike. The SDG also indicated that STEM education provides learners with the knowledge, skills, attitudes, and behaviours required for inclusive and sustainable societies. Hence, leaving out girls and women in STEM education and careers is a loss for all (UNESCO, 2017). Although some governmental and non-governmental agencies in Ghana have laid down some policies and activities to foster the involvement of young girls in science and mathematics programmes (Fletcher, 2009; Mukhwana et al., 2020),

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several authors (e.g., Acheampong, 2014; Saucerman & Vasquez, 2014) have highlighted some psychological barriers that already exist for young girls which has a negative implication and conveys messages about gendered social roles and expectations. Most female students lack mathematical self-efficacy, confidence, and self-esteem as a result of the psychological barriers associated with their study of mathematics (Gunderson et al., 2012). According to Cordova-Wentling and Camacho (2006), some societal practices have devalued female students with respect to their mathematical ability and achievements. Generally, females in Ghana are trained up to conform to certain gendered societal career profiling. Adusah- Karikari, (2008) discovered that most Ghanaian children are socialized from birth into male and female cultures by labelling some activities and programmes; such as Mathematics and Science as masculine and others such as Home Economics and Arts as feminine. In other words, female students are made to develop a narrowed belief about femininity and career choices due to the portrayal of mathematics as masculine. Most social structures such as the media and the educational system diffuse subtle and overt messages to the public by propagating a masculinized ideology of mathematics UNESCO (2017). As asserted by Acheampong (2014), the Ghanaian society holds the belief that femininity and the characteristics of mathematics are mutually exclusive. This means that males and mathematics are socially defined as or assumed to be analytical, objective, impersonal, rational and logical (Nosek et al., 2002). On the other hand, women are perceived by society to be intuitive, subjective, personal, irrational, and emotional. According to Henrion (1997), the belief of mathematics as masculine has influenced mathematical practices in a variety of ways that disadvantage prospective and professional female mathematicians. As a result, most successful female mathematics and science professionals are managing a duality of being feminine and scientific (Acheampong, 2014; Boateng, 2015; Ofosu-Mireku, 2005).

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Sadly, being a mathematician or scientist as a woman means sacrificing femininity (Henrion, 1997).

In support of the assertion of Adusah- Karikari (2008) on the effects of socio-cultural practices on female mathematics achievement in Ghana, Acheampong (2014) and Ofosu-Mireku (2005) postulated that a role conflict exists between the feminine identity and attaining STEM higher degrees and careers. Role conflict results from a combination of limited time and energy with additional roles and responsibilities that necessarily create tensions between conflicting demands and cause a sense of overload (Marshall & Barnett, 1993). In the Ghanaian culture, marriage and motherhood are emphasized as the primary goal of every woman, hence, society frown upon or hinders young girls' chances of pursuing higher degrees particularly in STEM disciplines (Adu-Yeboah, 2011). According to Adu-Yeboah (2011), there is an anxiety that a girl's marriage prospects will diminish if she obtains a higher degree, especially in a male-dominated fields. However, most women who are married find it challenging to handle multiple roles, that is, combining family, academics and career. Boateng (2015) argues that due to Ghanaian women's domestic roles as homemakers and child bearers, most of them, encounter difficulties in combining house management with the inhospitable and macho culture associated with STEM disciplines. Even though role conflict applies to women in all professions, women in STEM disciplines have unique experiences due to the discrimination and masculine culture associated with male-dominated fields where women (forming the minority) have to work harder to be recognized in these fields (Boateng & Gaulee, 2019; Buse et al., 2013). In addition, Adu-Yeboah (2011) and Ofosu-Mireku, (2005) highlighted that attaining a higher degree, especially in a STEM discipline is incompatible with motherhood and other domestic responsibilities, since it is time-consuming, demanding, and requires a lot of sacrifices. Hence, rising to the top

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as a female STEM professional means that one has to work very hard to prove one's worth at the expense of one's family (Adusah-Karikari, 2008). Moreover, when women in STEM fields prioritize their careers and desire to pursue higher degrees over household responsibilities, the home suffers the effect of a mother's psychological and physical disconnection, and it places additional weight of guilt and self-blame on women for being irresponsible mothers (Adu-Yeboah, 2011; Boakye, 2018).

The literature (e.g., Adusah-Karikari, 2008; Adu-Yeboah, 2011) indicated that gendered societal practices and expectations have been present since time immemorial. However, in sharing strategies and suggestions to help curtail the greater effect of socio-cultural beliefs and practices that female experience in STEM education and careers, some researchers (Boateng & Gaulee, 2019; Saucerman & Vasquez, 2014) postulates that society needs to address the issue of psychological barriers in place for young girls in Ghana by helping them develop a high sense of mathematical self-esteem; helping them gain autonomy, and also assisting them to cope with role conflict and discrimination. Changes in social norms and attitudes must take place and focus on providing support services as well as establishing a learning environment free of threat and considerate of the influence of prior socialization (Saucerman & Vasquez, 2014). With respect to this present study, socio-cultural experiences of female mathematics professionals in their educational and career journey, in addition to other obstacles they encountered have been identified, measured, and discussed.

2.7.1 The Experiences of Females in School vis a vis the Study of Mathematics

Several researchers (e.g., Asante, 2010; Boateng, 2015; Fletcher, 2009; Yarkwa, 2020) have found that in most Ghanaian schools, female students' study of mathematics is characterized by a lack of role models, inappropriate instructional methods, lack of

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careers guidance and peer support, in addition to gendered stereotyped practices in the classroom. The unfriendly and gender-insensitive method of teaching employed by most teachers in the mathematics classroom negatively impacts the performance and achievement of female students in mathematics (Boateng, 2015; Wedasango et al., 2011). UNESCO (2017) identified inappropriate teaching methods for being responsible for destroying the natural curiosity and inspiration of girls towards the study of mathematics. Although both boys and girls are affected by poor pedagogical skills at the elementary level, girls whose minds have already been conditioned by society to think of mathematics and science as a male domain are greatly affected. According to O'Connor (2000), female students in particular are prone to self-esteem issues that negatively affect their performance and sometimes can be very discouraging to the point where they leave the mathematics field. Similarly, in a study of the factors contributing to the negative attitude of female students towards the study of mathematics in Ghana, Salifu (2017) revealed that the inappropriate instructional methods have caused most female students to run away from the subject. Allotey (2012) also highlighted that the unfriendly method of teaching has made most female students to view mathematics as an abstract black box that contains nothing but complex, strictly held concepts and procedural imaginative formulae for memorization.

Furthermore, findings on Female Education in Mathematics and Science in Africa (of which Ghana is part), revealed that certain student-teacher interactions, unhealthy classroom environment, and teachers' stereotypical views about females in mathematics have discouraged and demotivated most female students from pursuing mathematics to the higher level (O'Connor, 2000). Boateng (2015) reported that some teachers in Ghana hold the stereotypical cultural belief that girls cannot do mathematics. Some teachers believe that the study of mathematics calls for struggle and determination, thus female

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students can't pursue mathematics degrees because girls don't have the capability to cope with "difficult" subjects (O'Connor, 2000). To the extent that some teachers throw discouraging and embarrassing comments at female students during mathematics lessons to the effect that they can never do mathematics (O'Connor, 2000). In addition, a study conducted by O'Connor (2000) and Wedasango et al. (2011) indicated that the low expectation for female students' mathematics achievement on the part of some teachers in Ghana has resulted in the kind of mathematics classroom dynamics, where girls are treated differently from boys. According to Frazier-Kouassi et al. (1992), both men and women in mathematics and physics majors agreed that the gender of a student has an effect on how the student is treated, and the female students were unanimous of the view that, it is women who are treated less positively. Similarly, Wedasango et al. (2011) opined that teachers direct more challenging and high-order thinking questions to boys, while only simple recall type of questions to girls, with the perception that girls are not good at mathematics. Bassi et al. (2018) also asserted that teachers pay more attention to boys and offer them more opportunities for hands-on practical work while the girls are given a less exploratory pedagogy.

2.7.2 Females in STEM's Experiences of Sexual Harassment

In Ghana, women face some levels of sexual harassment in science and mathematics professions and education (Boateng, 2015; UNESCO, 2017). Sexual harassment consists of three forms: gender harassment (verbal and nonverbal behaviours that convey hostility, objectification and exclusion of members of one gender); unwanted sexual attention (unwelcome verbal or physical sexual advances, which can include assault); and sexual coercion (when favourable professional or educational treatment is conditioned on sexual activity) (The National Academies of Sciences, Engineering, and Medicine [NASEM], 2018). NASEM (2018) reported that women commonly and

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disproportionately experience sexual harassment at multiple educational levels and careers. For instance, a survey conducted by Krebs et al. (2009) revealed that 20 to 50 percent of female students experience sexual harassment from teachers and peers, depending on their stage of education and field. A meta-analysis of studies also indicated that more than 30 percent of female students and professionals in male-dominated fields experience sexual harassment (Ilies et al., 2003). According to Atuahene and Owusu-Ansah (2013), sexual harassment undermines females' professional and educational attainment, leading to negative career outcomes. Similarly, UNESCO (2017) revealed that when female students experience sexual harassment, their educational outcomes include low academic (mathematics and science) achievement and greater truancy. The National Academies of Sciences, Engineering, and Medicine (2020) report emphasized that sexual harassment is a significant factor impeding the recruitment, retention, and advancement of women in mathematics and science, and its persistence in the workplace and education environments is putting at risk the gains made in improving the representation of women in these fields. According to Boateng (2015), most Ghanaian females in STEM have usually been victims of sexually suggestive jokes and were mostly accused of flirting with their lecturers or superiors.

2.7.3 Scarcity of Role Models

Role models are particularly essential to women in light of the fact that, the dearth of female role models in mathematics careers has been recognized as hinderance for women who desire to enter these professions (Fletcher, 2009). Hill et al. (2010) asserted that the presence of female role models in STEM subjects can mitigate negative stereotypes about gender-based ability and offer girls a genuine enlightenment of the various STEM careers. Stout et al. (2011) further expounded that role models enhance female students' self-perceptions and attitudes toward STEM, as well as their motivation to pursue STEM

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careers. Undeniably, research has shown that increasing the visibility of female role models in mathematics, whether on the screen, in the classroom, or at work, will help female students to see mathematics as a viable and attractive career option (Hill et al., 2010). As such, female students' encounter with role models should begin from their early stages as they journey through the educational ladder to the higher levels as well as their career entry. According to Aronson (2002), exposing girls to female role models can help them see their struggles as a normal part of the learning process rather than as a signal of low ability and this will in turn boost their mathematics achievements. Several scholars (e.g., Ofosu-Mireku, 2005; Yarkwa, 2020) have established that the scarcity of female role models in mathematics professions with whom girls in Ghana can relate has compounded to their underrepresentation in pursuit of mathematics degrees and careers. In a study conducted in Ghana, Fletcher (2009) delved into the participation of female undergraduate students in mathematics at the university level and the career they intend to pursue after graduating. Data for the study was obtained from three hundred and ninety-seven (397) undergraduate females in four public universities in Ghana using a questionnaire. The study revealed that generally the low participation of women in mathematics was mainly fuelled by the lack of role models and lack of information about the career opportunities with a degree in mathematics. Similarly, Wedasango et al. (2011) identified a lack of role models as one of the factors contributing to the poor persistence of female students in mathematics disciplines. Also, Hall and Suurtamm (2018) posited that in mathematics related fields where women are particularly underrepresented, surveys have found that more than 80 percent of women perceive a lack of female role models as a significant hurdle for gender inequity in their field.

According to Fletcher (2009) and Baryeh et al. (2000), most female students in Ghana receive very little to no career counselling regarding career paths in mathematics fields.

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The lack of information on career opportunities and scarcity of role models made it difficult for female students to have a clear insight into mathematical careers which would suit them (Khoza, 2017). Also, some female students reported that the lack of career guidance discouraged them from taking mathematics-related majors (Khoza, 2017). In essence, Mandina et al. (2013) recommended that parents and schools should invite prominent women who have excelled in mathematics-related careers and professions to share their thoughts and experiences regarding the reasons they entered the field, obstacles they overcame in relation to their career path, the type of work they do on a daily basis, practical information as well as positive and negative aspects of their jobs. Mandina et al. (2013) added that role models can be older students, and professionals in STEM academic, business and research environments. Similarly, Carrell et al. (2010) suggested that more female tutors should be recruited and retained since female students perform considerably better in their mathematics and science courses when their tutor is a woman. Carrell et al.'s (2010) assertion was supported by findings from Young et al., (2013) which state that female STEM professors presented several advantages to women without disadvantaging men, and all students assessed female STEM professors as more supportive role models than male professors. For women, seeing a female professor as a role model was connected to increased implicit science identity and decreased implicit gender stereotyping (Young et al., 2013)

2.7 Factors That Facilitated Resilience of Females in Male-Dominated Fields

Research has shown that women in male-dominated disciplines developed the ability to thrive academically despite many adverse situations which one encounters in pursuit of a male-dominated career (Condly, 2006; Thoman et al., 2020) The ability to thrive in difficult and challenging situations defines the notion of resilience. The theory of resilience explains why some students academically achieve even though they encounter

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many negative situations, capable of deterring such success (Reis et al., 2005). To establish benchmarks for the most commonly identified factors of resilience and persistence of females in mathematics-related programmes and careers, several major studies were reviewed. Most scholars (e.g., Adeyemi, 2013; Buse et al., 2013; Edzie, 2014; Thoman et al., 2020) found that resilient females are more likely to pursue higher degrees and retain in a male-dominated discipline based on two main resilience factors: internal factors and external factors.

2.8.1 External Factors

Researchers (e.g., Adeyemi, 2013; Cordova-Wentling & Camacho, 2006) identified family background variables such as parents' educational and occupational attainment as significant external factors in females' resilience in mathematics disciplines. According to the WECE (2002) report, most female students disclosed that having a family member (parent, sibling, or other relatives) who was an engineer was an essential factor in influencing their resilience to pursue engineering (Goodman et al., 2002). The female students indicated that relatives in engineering fields established a precedent for them to follow and also shaped their perception of engineering (Goodman et al., 2002; Hoffman et al., 2010). Similarly, resilient women in male-dominated professions reported that their parents' participation in STEM careers entrenched their mathematical aspirations, developed their personal aptitude in mathematics, and increased their efficacy belief in their mathematics achievements (Cordova-Wentling & Camacho, 2006). Adeyemi (2013) also asserted that, parents in STEM occupations provided immerse support and reinforcement of their female child's capabilities by bolstering their daughter's sense of competence and resilience in the field of mathematics. The findings from a longitudinal survey by Edzie (2014) indicated that parents in science and mathematics professions served as motivation and anchor for female students' resilience in mathematics

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disciplines, through their impact on female child's attitudes towards mathematics achievements, career-choice development, and future selections of mathematics and science-related majors. In addition, the findings of William (2019) highlighted parents' educational achievement as another great influencer of female students' resilience and persistence in mathematics and science career achievement. In quest of the external factors influencing the resilience of female students in male-dominated disciplines, William (2019) revealed that parents with high educational background hold less gender-stereotypic views of their daughters' educational and career attainment. This have been shown to positively affect girls' educational aspirations, self-esteem, and career orientation in male-dominated disciplines (Williams, 2019). According to Frazier-Kouassi et al. (1992) and Mau (2003), resilient women in male-dominated fields come from intact families, that is, have parents who are well educated and consider their female child's success in mathematics and science fields as vital. Mau (2003) argued that most female students from intact families gain early exposure to mathematical ideas, enjoy a quality mathematics-supportive home environment, and have easy access to mathematical resources. Similarly, a study conducted by Acheampong (2014) established that highly educated parents have the desire and the interest to afford the cost incurred on their female child's STEM education, hence facilitating the resilience and persistence of female students in STEM disciplines. Thus, parents of highly educated background guide, encourage and value the need for their female child to pursue STEM disciplines (Acheampong, 2014)

In addition, other scholars (Edzie, 2014; Cordova-Wentling & Camacho 2006; Heaverlo et al, 2013) have also identified the school variable as another great external influencer in the persistence and resilience of female students' mathematics and science achievement. A study conducted by Edzie (2014) revealed that female students'

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resilience to pursue higher degrees in mathematics programmes were intrigued by their performance and enjoyment of their mathematics and science classes (the teaching quality and encouragement provided by their teachers, as well as, the opportunity given to them to participate in extracurricular activities). Extra-curricular and co-curricular activities are noted to provide girls with experiential learning and investigative opportunities in academic areas that are not part of the regular school day, but play an integral role in shaping interest and confidence in STEM courses and careers (Bruyere et al., 2009). According to Edzie (2014) the involvement of female students in outreach programmes and out-of-school mathematics and science-related activities such as mathematics and science clubs, facilitated the development of female students' mathematics cognitive structure. Adding to Edzie (2014) findings, Matope (2007) longitudinal survey also established the school variable (mainly the teacher) as another external factor influencing female students' resilience in male-dominated in the twenty-first century. Findings from Matope (2007) revealed that teachers in more effective schools demasculinized and demystified mathematics and science by presenting mathematics as a subject that everyone can learn, which as a result improved and promoted female students' mathematics achievement and resilience in male-dominated career choices. Matope (2007), further found that teachers facilitated resilience in female students' mathematical achievement by exposing girls to role models and career information in mathematics; implementing instructional strategies that actively involve girls in mathematics lessons; supporting girls' mathematics and science endeavours by encouraging their interactions in and out of the classroom; as well as fostering girls' sense of competence and positive self-identity in mathematics. Furthermore, a study conducted by Adeyemi (2013) and Kaahwa (2012) revealed that female students' positive attitude towards mathematics, mastery of content and high mathematics self-esteem was as a

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result of the method of teaching and learning employed in the school. According to Frazier-Kouassi et al. (1992), the method of teaching that viewed learning as a constructivist approach created a closer connection between mathematics and girls' lives; and also improved the resilience of female students' interest and motivation in mathematics by providing a sense of purpose. Hoffman et al. (2010) also indicated that cooperative learning which engaged female students in active participation in the classroom activities facilitated their resilience and persistence in mathematics. Correspondingly, Dennehy and Dasgupta (2017) asserted that female students who took an active part in Peer-led team learning (PLTL); where students work in small groups to solve course-related problems with a peer mentor (a student who has previously been successful in the course), were persistent and resilient to pursue and attain higher degrees in male-dominated fields.

2.8.2 Internal factors

Mathematical self-efficacy has been identified by numerous researchers (Buse et al., 2013; Sawtelle et al., 2012; Williams, 2019; Zeldin & Pajares, 2000) as an influential internal factor for females' resilience and persistence in male-dominated programmes and careers. In an analysis to determine the resilience and retention of women in male-dominated fields, Buse et al. (2013) revealed that women in male-dominated disciplines attributed their resilience to their high sense of self-efficacy, strong coping skills, commitment and mental preparedness to be successful. Similarly, A qualitative study conducted by Williams' (2019) also highlighted that, resilient female students who demonstrated high self-efficacy belief persisted in a mathematics major or career choice than females with lower self-efficacy, as the former showed a strong belief in their ability to perform and become successful. Resilient female students related their high sense of self-efficacy to the satisfaction associated with successfully performing mathematics

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tasks (Williams, 2019). According to Zeldin and Pajares (2000), self-efficacy contributed to increasing female students' likelihood of persisting in disciplines such as mathematics and science where their mathematical abilities are challenged. A study conducted by Buse et al. (2013) to find out why women persist or did not persist in a male-dominated field revealed that women with sustained male-dominated careers demonstrated a high sense of self-efficacy belief and a purposeful adaptation to the macho culture found in male-dominated professions than women who leave the profession. Buse et al. (2013) concluded that more female students might persist in male-dominated programmes if institutions developed better retention programmes that develop the mathematical self-efficacy of female students and also prepare female students mentally for the rigorous nature of male-dominated programmes. According to Edzie (2014), women who are resilient possess high mathematical self-efficacy which enables them to overcome gender stereotypes, compensate for anxiety in mathematics, and also portray confidence in their achievement when it comes to choosing a mathematics-related major because of their mastery experience.

2.8 Support Systems That Influence the Success of Females in Male-Dominated Disciplines

Social support can be defined as an individual's perception of general support or specific supportive behaviours (available or enacted upon) from people in their social network, which enhances their functioning and may buffer them from adverse outcomes (Malecki et al., 2000) (Social support systems may include people such as friends, family members, and peers, as well as groups of individuals in specific institutions or circumstances. Utilizing social support systems encourages students (especially females) to cope with the diverse academic and social demands they face (Crosnoe et al., 2008). According to Jackson (2013) the importance of support systems is very essential when

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referring to a population (like females) that has experienced challenges entering and persisting through STEM areas of study. Relevant to the present study, Adeyemi (2013) and Robnett (2013) found that perceived social support (in this case, from parents, peers, and teachers) influenced mathematical achievement among females. In addition, monetary support (scholarships) was also highlighted as it directly influences the success of most females in the mathematics field (Mukhwana et al., 2020)

2.9.1 Family Support

Researchers (e.g., Jackson, 2013; Whiston & Keller, 2004; Williams & Emerson, 2019) have revealed that family support plays a pivotal role in building children's early interest in mathematics, thus, a foundation crucial for improving girls' achievement in mathematics as well as their desire to pursue mathematics-related careers. Hill et al. (2010) posited that when parents interact with girls and support their effort, girls perform better in mathematics and are more likely to excel in mathematics in the future. UNESCO (2017) asserted that when parents give more encouragement to their daughter for participating in mathematics and science-related activities, girls develop a high confidence and interest in STEM careers.

According to Mandina et al. (2013), parental support to their female children by encouraging them to explore and familiarizing themselves with resources that enlighten their world also influence their motivation to choose a male-dominated programmes of study. In addition, female students raised in homes that nurture self-confidence, competence, autonomy, and self-efficacy will take on challenging task (Aunola et al., 2013; Hoffman et al., 2010). However, when female students do not have the basic competence and ability, they seem not to have the freedom to engage in challenging

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academic pursuit like mathematics. This makes the home and the environment the female child grows in up an important component in girl child's academic development.

2.9.2 School Support

Teachers, learning contents, assessment methods and tools, materials and equipment, the overall learning environment and the socialisation process in school, are all critical to ensuring females' success and engagement with mathematics programmes and, ultimately mathematics careers (UNESCO, 2017). Teaching quality and specialisation in mathematics are essential for good quality mathematics education for female students. According to Zeldin and Pajares (2000), belief formation in female students about their mathematics successes and failures begins as soon as they start schooling. Mukhwana et al. (2020), and Zeldin and Pajares (2000) further asserted that the schools' goals, policies, and procedures interact with the climate in the classroom to affirm or alter girls' mathematical efficacy beliefs and attitudes. In addition, Mukhwana et al. (2020) revealed that teachers' support, especially those teaching mathematics at lower levels of education is an essential factor that propelled girls to develop an interest in STEM-related careers. Likewise supportive lecturers at higher levels of education also played a key role in ensuring that women succeed in STEM. The support from teachers was mainly in form of encouragement to the girls and letting them know that they had the potential to succeed just like their male counterparts (Mukhwana et al., 2020)

Additionally, some scholars (e.g., Luttenberger et al., 2019; Mukhwana et al., 2020; UNESCO, 2017) have outlined several support strategies the school can adopt to increase girls' interest and success in mathematics right from their primary stage. Among these measures are:

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- more female teachers should be trained to handle mathematics in schools to serve as role models for female students and as well erase the notion that mathematics is a masculine subject.
- introduction of reward packages for female students who excel in mathematics and other science-related subjects.
- there is a need for mentors as well as guidance and counselling coordinators in schools to help students develop an interest in mathematics.
- mathematics teachers must use appropriate teaching methods as well as innovative teaching and learning materials to make the subject more appealing and interesting to the female students.
- there is also the need to organize mathematics quiz and competitions for girls with attractive motivational packages for those who excel.
- teachers should connect abstract learning to a concrete situation by adopting the case-study method that has proven effective for students, thus applying abstract theories and concepts to real-life scenario to make sense of situations involving real people and stakes

2.9 The Relationship Between Support Systems and Students' Resilience in Mathematical

Student's mathematical resilience is not static, it can be increased or reduced (Hutauruk & Priatna, 2017). A student will feel safe in taking risks to develop their mathematics abilities when they have a social support system (such as parents, teachers, peers, etc.) who will encourage, respect, affirm, model resiliency, and refrain from passing negative judgment (Hutauruk & Priatna, 2017; Unsal et al., 2018). Johnston-Wilder et al. (2015) opined that support systems helps learners to identify for themselves when they are in

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their mathematical growth zone, and encourages learners to value the challenges it brings as well as manage the emotions that comes with it. As such, some scholars (e.g., Agasisti et al., 2016; Chirkina et al., 2020; Ünsal et al., 2018) have investigated the relationship between various support systems and students' resilience. Earlier studies (Arastaman, & Balci, 2013; Chirkina et al., 2020; Liew et al., 2018; Unsal et al., 2018) found a positive significant correlation between school support variable (school related factors) and students' resilience in mathematics. Chirkina et al., 2020 emphasized that a conducive school environment and the teachers' value for mathematics increases the resilience of females in mathematics. According to these researchers (Chirkina et al., 2020; Erberber et al., 2016; Agasisti et al., 2016), in countries where teachers demonstrate a high level of confidence in students' abilities and educational aspirations, there is a high proportion of resilient students.

In addition, other studies (e.g, Arastaman, & Balci, 2013; Tok & Ünal 2020) found a strong positive correlation between family support system and students' resilience in mathematics. Cheung et al. 2017 reported that students with family support tend to have better psychological wellbeing, and were more likely to be resilient in mathematics. Arastaman and Balci, (2013) found that supervision by parents and time spent on mathematics at home had a positive effect and strengthened students' resilience in mathematics.

2.10 Summary

The review of literature uncovered how individuals utilize the resilience theory (thus, internal and external protective factors) to enable success. Success is often not instantaneous. Instead, success often comes through a cyclical process that entails identifying strengths and weaknesses and implementing strategies to become successful.

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Likewise, the review pointed out that individuals who are with a strong sense of self-efficacy mostly take-up difficult tasks (like mathematics-related programmes) that are challenging and are mostly motivated intrinsically. Social support systems like family support and school support which facilitates success of females in male dominated disciplines were also discussed.

The review of literature has provided a fair idea on the experience of African women in higher education and specifically Ghanaian women in mathematics-related programmes. The studies revealed that women are underserved educational wise through the lack of role models, socio-cultural beliefs and practices as well as application of inappropriate instructional methods. Culturally children most especially girls, grow with the stereotypical view that mathematics and science programmes are for boys and art and home economics are for girls (Ekine et al., 2013).

Additionally, studies (Reilly et al., 2017; Sorby & Baartmans, 2000) reviewed have dismissed the line of thought that girls' brains develop differently from boys', and that these biological differences explain the gender gap in mathematics and science. To complement this assertion, UNESCO (2017) posits there is evidence that in some countries, girls perform as well as or even better than boys in mathematics and science.

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CHAPTER 3

METHODOLOGY

3.0 Overview

This chapter outlines the research methodology that was used in the study. It was discussed under the following sub-topics; research approach, research design, population, sample and sampling procedure, instrumentation, validity and reliability of the research instruments, trustworthiness, pilot testing, data collection procedure, data analysis, and ethical considerations.

3.1 Research Approach

The selection of a research approach is based on the nature of the research problem, the researchers' personal experiences, and the audiences for the study (Creswell & Creswell, 2018). Creswell and Creswell (2018) further outlined three major components of a research approach; the Philosophical Worldviews (Postpositivist, Constructivist, Pragmatic, etc.), the Research Design (Experimental, Ethnography, Explanatory sequential, etc.) and the Research Methods (data collections, data analysis, validation, etc.). According to Creswell (2009), there are two general approaches to a research study; the quantitative and qualitative research approaches. However, significant enlightenment among scholars (e.g., Creswell & Creswell, 2018; McMillan & Schumacher, 2014) have established that the combination of both qualitative and quantitative approaches in studying a single phenomenon forms the third research approach (known as a mixed method approach). This study employed a mixed method approach. According to Hussein (2009), the mixed method approach is considered as a third research approach in addition to the qualitative and quantitative research approaches. Creswell (2014) opined that the mixed method approach helps the researcher to develop a rich

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understanding of various occurrences of interest that cannot be completely understood using only a quantitative or a qualitative approach. The combination of quantitative and qualitative methods sheds light on the same item from different viewpoints and in different techniques, thus giving a more comprehensive and valid image of the phenomenon under study (Creswell, 2014). Moreover, both qualitative and quantitative approaches have their own strength and weaknesses, hence combining the two approaches will neutralise the flaws of one method and strengthen the benefits of the other for better study results (Creswell, 2012; Hussein, 2009). Venkatesh et al. (2013) noted that generally, a mixed method approach uses quantitative and qualitative study approaches, either concurrently (i.e., independent of each other) or sequentially (i.e., findings from one approach inform the other), to comprehend a phenomenon. Relating to this study, the quantitative and qualitative study approaches were implemented sequentially (where priority was given to the quantitative approach) to gain a detailed understanding of the respondents' (female mathematics professionals) life experiences as well as the elements that facilitated their resilience in this highly androcentric field from different viewpoints.

3.2 Research Design

A research design is a logical plan which details out directions for a researcher in a study regarding the collection, analysis and interpretation of data on a phenomenon (Creswell, 2009; McMillan & Schumacher, 2014). According to McMillan and Schumacher (2014), designing a study helps the researcher to plan and implement the study in such a way as to help the researcher obtain the intended results. By so doing, increases the chances of obtaining information that might be associated with the real situation. Relating to this study, the researcher collected both quantitative and qualitative data in order to attain the most valid and credible conclusions to the answers to the research questions (Creswell,

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2009). For this survey, the researcher employed one of the mixed-methods approaches known as the sequential explanatory design or the explanatory sequential design. According to Creswell (2014), sequential explanatory design is also known as the two-phase model, and "it is characterized by the collection and analysis of quantitative data in the first phase of research followed by the collection and analysis of qualitative data in a second phase to help explain the initial quantitative results" (p.211). In addition, the study combined both quantitative (questionnaires) and qualitative (semi-structured interview) data collection instruments to gain a greater insight into the research problem since one approach can be used to build on the results of the other approach (Creswell, 2009). The sequential explanatory design also granted the researcher a broader view of the life experiences of the female mathematics professionals from different perspectives, thus, contributing to a fuller understanding of the research questions.

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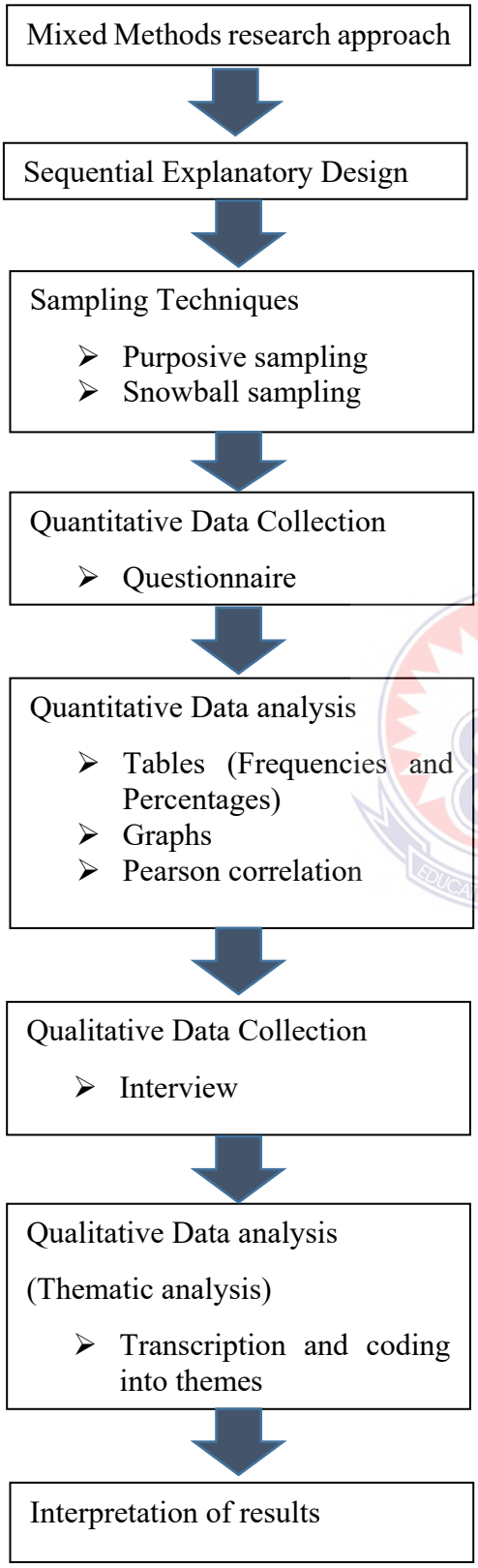
Figure 2.

The framework of the study design



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3.3 Population

McMillan and Schumacher (2014) described a population as a group of elements or cases, whether individuals, objects, or events, that conform to specific criteria and to which the researcher intends to generalize the results of the research. As a mixed method approach, the target population is determined by using selected criteria that uncover the most eligible potential participants just as stated by Asiamah et al. (2017). That is, the research focuses on participants who can best share experiences and thoughts to address the research goal.

The target population of the study was successful female mathematics professional from public Universities in the Greater Accra and Central Regions of Ghana.

3.4 Sampling and Sampling Techniques

According to Gerrish and Lacey (2010), a sample is a subset of a target population, normally defined by the sampling process. For the purpose of this study, 70 female mathematics professionals were selected through a purposive sampling technique; 10 female lecturers and 60 female MPhil students (who are mathematics professionals) in Ghanaian tertiary institutions in Greater Accra and the Central region. The 70 participants were selected on the basis that the study demands inferential statistics which requires that the number of participants should be more than 30. Also, the population was not discrete, so the study employed the snowball sampling technique which was based on recommendation by participants. With purposive and snowball sampling techniques, the researcher was able to identify and select participants that are proficient and well informed with the phenomenon of interest the two Regions. According to McMillan and Schumacher (2014), purposive sampling is a non-probability sampling method and it relies on the judgment of the researcher to select a sample that is representative of the population or that includes subjects with needed characteristics. The choice of Ghanaian

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tertiary institutions is not arbitrary but seems appropriate to be considered for participation in a study like this. Besides easy access to faculty members, it can also be established for their minimum academic qualifications.

In addition to the purposive sampling technique, the researcher employed Snowball sampling as a strategy to access female mathematics lecturers. According to McMillan and Schumacher (2014), Snowball sampling also known as network sampling is a strategy in which each successive participant or group is named by a preceding group or individual. Snowball sampling assisted the researcher in the selection of participants because of the criteria for selection

3.5 Research Instruments

Two data collection instruments were used in the study: a questionnaire (an online survey) and a semi-structured face-to-face interview.

3.5.1 Questionnaire

The questionnaire consisted of four (4) sections: A, B, C, and D. Section 'A': background information of respondents and this was in line with the research since these variables helped the researcher to make conclusions from the views of respondents. Section 'B': life experiences of respondents whilst pursuing mathematics. Section 'C': Factors that facilitated resilience of respondents in a male-dominated field. The last section 'D': Support Systems that influence the success of respondents. The questionnaire consists of 41 items and requests straight forward, concise and brief answers (see Appendix A).

The questionnaire comprised of mainly close-ended items which demanded respondents to select responses that best apply to them. The questionnaire items were on a five-point Likert Scale namely, Strongly Agree (SA), Agree (A) Neutral (N), Disagree (D), and

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Strongly Disagree (SD) which employed a graded response to each of the statements. The scores were in the order from Minimum (1) to Maximum (5), a response intensity of Strongly Agree (SA) which was the highest was scale as 5, Agree (A) rated 4, Neutral (N) as 3, Disagree (D) scored as 2, whereas Strongly Disagree (SD), the lowest response intensity was scored as 1 for sections B, C and D. The items were built to reflect on the key themes raised in the research questions.

In educational research, the questionnaire is known to be the most common data collection instrument used which is more familiar to respondents (McMillan & Schumacher, 2014). The mixed method approach typically employs the questionnaire and interview data collection methods to determine the opinions, attitudes, and perceptions of participants of the phenomenon (McMillan & Schumacher, 2014). With the aim of the researcher to investigate the life experiences of female mathematics professionals, it was appropriate to use a questionnaire (an online survey). The questionnaire was a preferred option due to the secrecy of its nature. McMillan and Schumacher (2014) outlined three general benefits of questionnaires: consistency of presentation of questions to the respondents, relatively economical and less time-consuming to administer. In addition, designing and administering questionnaires utilizing an online survey tool has become a common data collection instrument in today's networked environment (Vasantha-Raju & Harinarayana, 2016). According to Vasantha Raju and Harinarayana (2016), online surveys are more reliable than face-to-face surveys because it has replaced the adversaries of high cost, wastage of paper, long travel and time consumption.

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3.5.2 Interview Guide

Patton (2002) contends that qualitative interviewing begins with the assumption that the perspective of others is meaningful, knowledgeable, and should be able to be made explicit. Interviews are by their very nature social encounters where speakers collaborate in producing retrospective and prospective accounts or versions of their past and future actions, experiences, feelings, and thoughts (McMillan & Schumacher, 2014; Patton, 2002). In other words, an interview is a purposeful conversation, usually between two people, although sometimes involving more, that is directed by someone in order to get information from the other (Bogdan & Biklen, 2003). With reference to mixed method research approach, interviews may be used in two ways. They may be the dominant strategy for data collection, or they may be employed in conjunction with participant observation, questionnaires, or other techniques (Creswell, 2009; Fick, 2009).

For the purpose of the study, the researcher developed a semi-structured interview guide for the data collection (See Interview Protocol in Appendix B). The semi-structured interview method is successful in enabling reciprocity between the interviewer and participant thus aiding the interviewer to improvise follow-up questions based on the participant's responses (Kallio et al., 2016). The method allows the researcher to collect open-ended data by exploring participants' thoughts, feelings and beliefs about a particular topic and delving deeply into issues pertinent to them (Bradford & Cullen, 2012; Choak, 2012). In this regard, the researcher employed open-ended questioning strategy to attain more information about respondents' life experiences as well as the support systems that influence their success in a male-dominated field.

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3.6 Data Collection Procedure

In conducting a study, Creswell (2009) advises researchers to seek and obtain permission from the authorities in charge of the site of the study because it involves prolonged and extensive data collection. In line with Creswell (2009), an introductory letter was obtained from the Head of the Department of Mathematics Education at the University of Education, Winneba. This letter provided the details of the study, including data collection, and issues of confidentiality and anonymity. This letter was used to obtain permission from the interviewees. Approval was then given to the researcher by the interviewees for data collection. All interviews were audio recorded and transcribed. The researcher sought permission from interviewees to record the interviews and to take notes and also assured the interviewees of anonymity. The interview lasted a range of 40- 80 minutes. In all, 10 female mathematics professionals were interviewed comprising 6 female lecturers and 4 MPhil mathematics female students. For clarification and further explanation of views that were unclear or required further explanation, there were follow-up interviews.

3.6.1 Administering of Questionnaires

Since online surveys has an upper hand regarding response speed, costs, and response rate (Vasantha-Raju & Harinarayana, 2016), the questionnaire was developed and administered using Google Forms (an online survey tool). The Google Form was a convenient and fast means of creating online questions with responses. Gathering feedback from respondents is very effective, easier, and very convenient for the respondents and the researcher (Bennet, 2016). Utilizing the purposive and snowball sampling techniques, the electronic links were sent to selected respondents through email addresses and WhatsApp numbers.

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3.7 Validity of the Research Instrument

To ensure the validity of the research instruments, the researcher followed established best practices. According to Creswell (2009), the validity of a study is defined as the extent to which the research instruments accurately measure what they are intended to measure. In this context, the researcher took specific steps to ensure content validity by consulting with experts.

The researcher engaged in a consultative process involving both academic supervisor and two experts from the Department of Mathematics Education at the University of Education. This approach aligns with the recommendation of Babbie (2016), who emphasizes the importance of involving experts to assess and validate research instruments. In the case of this study, the expertise of the individuals involved was essential in assessing the questionnaire items and semi-structured interview questions.

The goal of this consultation was to evaluate the content validity of the research instruments, ensuring they accurately captured the dimensions and aspects relevant to the research questions. Content validity is a crucial component of instrument validation, as emphasized by DeVellis (2017). The reviewers provided valuable feedback and recommendations, resulting in necessary modifications to the questions. This process enhanced the research instruments' alignment with the study's objectives and ensured that they measured what they were intended to measure, as per the definition of content validity by Haynes et al. (1995).

By consulting with the supervisor and experts and adjusting based on their recommendations, the researcher successfully strengthened the content validity and reliability of the research instruments, aligning with the best practices in the field of research methodology. This rigorous approach to instrument development is fundamental to producing credible and dependable research results (Bryman & Bell, 2015).

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3.7.1 Pilot Testing of the Questionnaire Instrument

According to Creswell (2012), pilot testing is a procedure in which a researcher makes changes in an instrument based on feedback from a small number of individuals who complete and evaluate the instrument. In this study, the questionnaire was tested by administering it online using google forms to about twenty (20) female mathematics professionals who were not part of the main study. Based on the feedback from the pilot testing, the researcher revised the instrument before sending it out to the sample in the study. For example, some poorly worded questions and responses that do not meet the objective of the study were rephrased. The goal of pilot testing a questionnaire was to ensure internal consistency. Internal consistency is evaluated in scales and tests that involve summing items (Polit & Beck, 2014). Generally, the common method for determining a questionnaire's internal consistency is to compute the coefficient alpha, also known as Cronbach's alpha (Polit & Beck, 2014). Cronbach's alpha is mostly applied in a research study when multiple items are used to measure a construct (Tavakol & Dennick, 2011). Lee Cronbach developed the Cronbach Alpha formula in 1951 to measure how internally consistent a test is along the scale of 0 to 1 construct (Tavakol & Dennick, 2011). Based on the responses of the pilot group, Cronbach's alpha was used in this study to determine the internal consistency reliability of the questionnaire. The SPSS (version 21.0) was used to calculate the Cronbach Alpha of the study

Cronbach's alpha ranges from 0.00 to 1.00 with all values between 0.00 and 1.00 also being valid. Zero indicates that there is no correlation between the items at all. They are entirely independent. This means that knowing the value of a response to one question provides no information about the responses to the other questions. Moreover, one indicates that they are perfectly correlated. In short, knowing the value of one response provides complete information about the other items. For instance, if one gets a value of

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0.90, it means that 90% of the variance in the scores is reliable, whilst 10% is unreliable (Brown, 2002).

3.7.2 Reliability of the Research Instruments

Concerning every research design, "instruments chosen for the collection of data must pass the tests of validity and reliability before they can be considered good measures" (Dikko, 2016, p. 521). Likewise, the questions of reliability are essential in any research as the credibility of a research study depends on the reliability of the data, methods of data collection, and also on validity of the findings (Cohen et al., 2011; Creswell, 2009). According to Yavuz et al. (2012), Reliability is the extent to which results are consistent over time and an accurate representation of the total population under study. Also, if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable (Yavuz et al., 2012). Reliability also measures the precision, repeatability, consistency, and trustworthiness of research (Cohen et al., 2011). This means that a high degree of stability indicates a high degree of reliability. In this study, the researcher used the SPSS (version 21.0) to compute the Cronbach alpha after the pilot study. The Cronbach's alpha for all the 41 items was 0.834 (see Appendix C) indicating that the internal consistency and reliability of the questionnaire was excellent (Brown, 2002; Cohen et al., 2011).

3.7.3 Trustworthiness of Qualitative Findings

In every qualitative result presentation, trustworthiness essential. Trustworthiness has to do with the ability to determine whether the findings of a study actually represent the participants' voices and can be trusted (Elo et al., 2014; Polit & Beck, 2014). According to Polit and Beck (2014), the trustworthiness of a study refers to the degree of confidence in data, interpretation, and methods used to ensure the quality or rigour of a study. A

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number of concepts have been propounded by Lincoln and Guba (1985) as the major criteria for establishing trustworthiness in qualitative research. They include credibility, transferability, dependability, and confirmability. Thus, the researcher ensured trustworthiness in the study using the above criteria.

Establishing credibility entails demonstrating that the findings of qualitative research are legitimate from the perspective of the research participant (Connelly, 2016; Polit & Beck, 2014). As qualitative research studies explore people's views, experiences, feelings, and beliefs, it is believed that the respondents are the best judges of whether or not the study findings truly reflect their opinions. Thus, credibility, which is equivalent to internal validity in quantitative research, is measured by the level of respondent concordance, which is achieved by presenting the findings to those who participated in the study for approval, validation, confirmation, and congruence (Connelly, 2016). The higher the outcome, the greater the study's validity (Polit & Beck, 2014). To ensure the credibility of the study, the researcher purposefully recruited respondents who met the criteria and could provide detailed information about their life experiences in the mathematics discipline. Credibility was further enhanced in the study through member-checking. According to Creswell (2009), member-checking involves allowing participants to read the transcripts of their interviews to ensure that they have been accurately recorded and hence credible. Basically, transcripts of the interview were taken back to participants to verify the accuracy of the theme in the findings. Debriefing by the supervisor was also used to ensure that coding procedures were clearly presented and data interpretation was consistent.

Transferability refers to the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings (Connelly, 2016; Polit & Beck,

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2014). Transferability is also similar to external validity in quantitative research (Lincoln & Guba, 1985). Though it is very difficult to prove transferability primarily because of the approach a researcher employed in the qualitative research, it can be accomplished to some extent if the researcher extensively and clearly details the process used for others to follow and replicate (Elo et al., 2014; Polit & Beck, 2014). Transferability was attained in the study through a vivid description of the method used in collecting data and the length of data collection. Additionally, the researcher outlined a detailed and thick description of themes in order to give explicit accounts of how conclusions were drawn from the study. Finally, the analysis of the transcribed data was recorded for reference. This will provide the means for other researchers to transfer the conclusions of the study to other contexts.

Dependability in the framework propounded by Lincoln and Guba (1985) is synonymous with the concept of reliability in quantitative research. It is concerned with the consistency of the data collection over a period of time and conditions (Connelly, 2016; Polit & Beck, 2014). Moreover, since qualitative research advocates flexibility and freedom, establishing dependability may be difficult unless you retain an extensive and detailed record of the methods for others to replicate (Elo et al., 2014; Polit & Beck, 2014). In achieving dependability in the study, the researcher maintained an audit trail by giving a transparent and in-depth description of the research design, and the methods used in collecting and analysing the data. The researcher also employed the services of experts in a qualitative study to critique the processes and findings of the study. The purpose was to evaluate the accuracy and assess whether or not the findings, interpretations, and conclusions were actually consistent with the data.

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Confirmability refers to the congruence between two or more independent people about the data's accuracy, relevance, or meaning (Polit & Beck, 2014). Confirmability is also similar to objectivity in quantitative research (Lincoln & Guba, 1985). It is only possible if both researchers follow the process in the same way for the results to be compared. Confirmability also refers to the researchers' ability to demonstrate that the data represent the participants' responses and not the researcher's biases or viewpoints. In ensuring conformability, the researcher reflected on her own biases and prejudices while bracketing and controlling them before and during data collection and analysis. Additionally, transcripts were reviewed by the supervisor, and a peer review strategy was also used to correct errors and provide further clarification where necessary.

3.7.4 Pilot Testing of the semi-structured interview guide

According to McMillan and Schumacher (2014), after the interview guide has been written, a pilot test is necessary as a check for bias in the procedures, the interviewer, and the questions. However, Campell (2015) asserted that conducting a pilot test on a qualitative study particularly an interview guide is rare and sometimes not essential. Campell (2015) later emphasized that despite the rarity of testing an interview guide, if a pilot study is conducted on an interview guide, it helps in refining the guide. In addition, some researchers (Campell, 2015; Dikko, 2016; McMillan & Schumacher, 2014) in recent studies have highlighted the following as benefits of piloting an interview guide for a study

- it helps the researcher to evaluate an appropriate length of time for the interview
- it aids the researcher to identify unclear or ambiguous statements in the interview guide
- it allows the researcher to practice and perfect interviewing techniques

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- it helps the researcher to determine whether all vital questions have been incorporated to measure all concepts

In relation to the benefits of pilot testing an interview guide, a pilot study was conducted with three female mathematics professionals who were not included as respondents in the main study. The pilot testing of the semi-structured interview guide aided the researcher in appropriately constructing the questions and eliminating some of the questions that did not seem to serve a purpose at all. The researcher made resolutions during the pilot testing, to ensure that the choice of respondents, the setting, and interview procedures were as close as those intended in the main study as possible. The pilot testing interview lasted for 25 minutes on average.

3.8 Data Analysis

The data analysis procedure included two main phases: the responses from the questionnaires were analysed quantitatively and the responses from interviews were analysed qualitatively.

3.8.1 Quantitative analysis

Descriptive and inferential statistics were employed in the analysis of the quantitative data collected. Descriptive statistics was used to analyse research questions one to three and the inferential statistics was used to address research question four. The responses from the questionnaire items were coded and analysed through the use of the International Business Machine Statistical Package for the Social Sciences (IBM-SPSS) version 21.0. The descriptive analysis seeks to organize and describe the data by investigating how the responses are distributed on each construct, and by determining whether the responses on different constructs are related to each other. The data were expressed in percentages and represented in graphs and tables.

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3.8.2 Qualitative analysis

Thematic analysis was used to analyse the qualitative data based on the questionnaire. Thematic analysis is the process of identifying patterns and themes within the data (Flick, 2009). In other words, the researcher organizes excerpts from the transcripts into categories which will be connected to form themes. In accordance with Flick (2009), the following steps were taken:

1. the recorded audio was transcribed.

2. the transcripts were read and notes about the first impression were made. The transcripts were then re-read one after the other and line by line.

3. relevant pieces such as words, phrases, sentences, or sections were labelled. The labels were about actions, activities, concepts, differences, opinions, processes, or any relevant information. This is referred to as coding/indexing. To determine how relevant a piece of certain information is, the researcher considered the following:

(a) is the information repeated in several places or respondents?

(b) does it surprise the researcher?

(c) was it insisted by the interviewee?

(d) have the researcher read about it in any article or published report?

(e) does it remind the researcher of a certain theory or concept?

(f) is it superficial or conceptualization of an underlying pattern?

4. the researcher made sure there was no bias in the coding process. The opinion of the participants was accepted and every relevant statement or response by the participants was recorded without the researcher's personal interpretation. The researcher then decided which of the codes was very important and categories were created to put several codes together in themes. Important codes were then grouped and the data conceptualized. The categories were then labelled and the relevant ones were considered.

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3.9 Ethical Consideration

Information acquired from respondents must be kept confidential (Cohen et al., 2011). According to Kusi (2012), in educational research ethics are the issues that are related to how the researchers conduct themselves and the consequences of their practices on the participants of the study. Similarly, Cohen et al. (2011) suggested two concerns to watch out for in ethical considerations; first, how the research has been conducted in relation to the research subject (matters such as informed consent, confidentiality, and persons involved). Secondly, acknowledgment of the contributions of all the people who have been involved in the research, as well as open recognition of individuals whose research influenced this present study. Due to this, participants were informed about the study and its purpose, and their consent was sought before their engagement in the study. Engagement with the participants was made possible by an introductory letter obtained from the Mathematics Department of the University of Education, Winneba. Additionally, pseudonyms were used for each interview participant to ensure anonymity. The researcher kept all of the data collected confined for the purposes of the study, and also secured privacy.

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CHAPTER 4

DATA ANALYSIS AND DISCUSSION

4.0 Overview

This chapter focuses on the results from the analyses of the data obtained and discussion of the findings that emerged from the data collected using questionnaires and interviews. The purpose of the study was to investigate the life experiences of female mathematics professionals and also find the factors that facilitated their resilience in a male-dominated field. The presentation begins with the demographics of respondents, followed by the discussion of themes based on the objectives of the study. The objectives of the study are:

1. to investigate the life experiences of successful female mathematics professionals in their educational journey.
2. to find the elements that facilitated the resilience of successful female mathematics professionals in the field of mathematics.
3. to determine the support systems that influence the success of female mathematics professionals.
4. To find out the relationship between support systems and females' mathematical resilience

4.1 Respondents' Demographic Characteristics

In the questionnaire, 5 items were designed to collect data on the demographic characteristics of the respondents. Respondents' responses were analysed descriptively and presented in Table 2, Table 3 and Figure 3. The demographic data of respondents include age, number of years in service, level of education as well as the academic level of respondents' parents.

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Table 2.

Demographics data of respondents

Demographic characteristics		Frequency (N)	Percentage (%)
Age	21-30	12	17.14
	31-40	36	51.43
	41-50	16	22.86
	Above 50 years	6	8.57
	Total	**70**	**100**
Years of Service	1 - 5	17	24.29
	6 - 10	33	47.14
	11 – 15	15	21.43
	Above 16 years	5	7.14
	Total	**70**	**100**
Level of Education	Bachelor's Degree (but pursuing master's degree)	60	85.71
	Master's Degree	3	4.29
	Doctoral Degree (Ph.D.)	7	10.0
	Total	**70**	**100**

Results from Table 2 revealed that, majority of the respondents (51.43%) were within the age bracket of 31-40 years which indicates that most of the respondents used in the study were in their youthful age and early stage of their mathematics careers, followed by respondents within the age bracket of 41-50 years which constituted 22.86%. The study also revealed that, 17.14% of the total respondents were within the age bracket of 21-30 years, and 8.57% of the total respondents were also above 50 years.

Also, the result from Table 2 showed that 47.14 percent of the respondents have been in the mathematics profession for 6 - 10 years as teachers, followed by 24.29% of the total respondents between 1-5 years of service. The study also revealed that 21.43% of the

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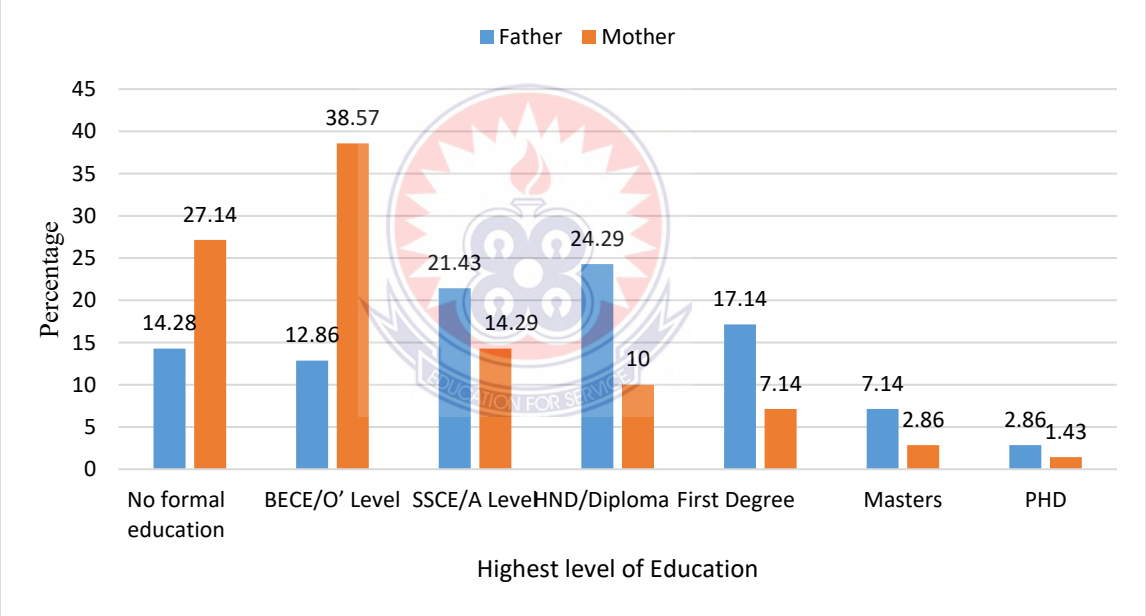
total respondents were within 11- 15 years of service and 7.14 % of the total respondents were above 16 years in service (see Table 2).

Additionally, the data in Table 2 indicated that, the majority of the respondents, representing 85.71% had attained a first degree but pursuing their master's degree in mathematics and 4.29% of the respondents had attained master's degrees. Moreover, 10% of the total respondents have attained their doctorate.

Figure 3.

Graphical representation of Parents' highest level of education



From Figure 3, the highest educational level of parents was classified into seven categories: BECE/O Level, SSCE/A Level, HND/Diploma, First Degree, Masters and PHD in addition to no formal education. More than three quarters of both fathers and mothers had completed at least basic school and pursued further studies (Figure 3). However, on the whole the fathers seem to have attained a higher level of education than the mothers have. The majority of the fathers (27.14 percent) have university degrees (17.14 percent for first degree, 7.14 percent for masters and 2.86 percent for doctorate).

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This is contrasted with 11.43 percent of mothers with university degrees (7.14 percent for first degrees, 2.86 percent for masters and 1.43 percent for doctorate). Results from Figure 3 also revealed that 24.29% of the respondents' fathers have obtained HND/ Diploma whiles only 10% of the respondent's mother have obtained HND/ Diploma. Moreover, 21.43% and 12.86% of the respondent's father have SSSCE/A' Level and BECE/O' Level certificates respectively. This is contrasted with 14.29% of mothers with SSCE/A Level certificate and 38.57 of mothers with BECE/O Level certificate. In addition, Figure 3 indicated that 14.28% representing 10 of respondents' father and 27.14% representing 19 of respondents' mother had no formal education.

4.2 Research question 1

What are the life experiences of successful female mathematics professionals in their educational journey?

Data were gathered to explore the life experiences of female mathematics professionals in their educational and career journeys. Although challenges are inevitable in every educational and career journey, female mathematics professionals have their own unique experiences in different forms. With the aid of a questionnaire and a semi-structured interview guide, the respondents were able to identify and voice out the challenges they encountered. The responses of the respondents were grouped into themes. The following are the themes that were developed: an unhealthy school environment, sociocultural practices and beliefs, managing multiple roles, and financial challenges

4.2.1 Unhealthy School Environment

The scale for answering consisted of Strongly Agree (5), Agree (4), Neutral (3), Disagree (2), Strongly Disagree (1). The number of respondents reported for each item is shown in Table 3.

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Table 3.

Unhealthy school environment

ITEMS	SA n%	A n%	N n%	D n%	SD n%
Whilst pursuing my education, most of my teachers applied inappropriate instructional methods during mathematics lessons	13(18.57)	40(57.14)	8(11.43)	8(11.43)	1(1.43)
	75.71%			12.86%	
Whilst pursuing my education, my school lacked adequate teaching and learning materials needed for the study of mathematics	18(25.71)	29(41.43)	14(20.0)	7(10.0)	2(2.86)
	67.14%			12.86%	
As a young lady pursuing mathematics, most of my teachers had negative attitude towards girls during mathematics lessons.	14(20.0)	13(18.57)	23(32.86)	13(18.57)	7(10.0)
	38.57%			28.57%	
As a young lady pursuing mathematics, I was not given enough counselling on the various careers associated with mathematics.	20(28.57)	34(48.57)	12(17.14)	3(4.29)	1(1.43)
	77.14%			5.72%	
As a young lady pursuing mathematics, there were no female mathematics role models to emulate	19(27.14)	34(48.57)	5(7.14)	9(12.86)	3(4.29)
	75.71%			17.15%	
Whilst pursuing my education, I mostly face difficulties due to the abstract nature of mathematics.	9(12.86)	8(11.43)	29(41.43)	18(25.71)	6(8.57)
	24.29%			34.28%	
As a young lady pursuing mathematics, my peers attribute my high performance in mathematics as a result to flirting with the tutors	10(14.29)	16(22.85)	10(14.29)	21(30.0)	13(18.57
	37.14%			48.57%	

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SA-Strongly Agree, A-Agree, N-Neutral, SD-Strongly Disagree, D-Disagree

Results from Table 3 revealed that 75.71% (N=43) of the total respondents cumulatively agreed with the statement that whilst pursuing their education, most of their teachers applied inappropriate instructional methods during mathematics lessons, 11.43% (N=8) respondents neither agreed nor disagreed and 12.86% (N=9) disagreed to the statement. Similarly, 47 respondents representing 67.14% of the total respondents agreed that while pursuing their education, their school lacked adequate teaching and learning materials needed for the study of mathematics, 14 respondents representing 20% responded neutral, while, 7 respondents representing 12.86% disagreed. Moreover, in responding to the statement "As a young lady pursuing mathematics, most of my teachers had negative attitude towards girls during mathematics lessons" 27 respondents representing 38.57% of the total respondents were in agreement, whereas 20 respondents representing 28.57% responded in disagreement and 23 respondents representing 32.86% were irresolute. Also, findings from Table 3 indicated that 54 respondents representing 77.14% agreed that as young ladies pursuing mathematics, they were not given enough counselling on the various careers associated with mathematics, whilst 12 respondents representing 17.14% were neutral, the remaining 4 respondents representing 5.72% disagreed. Similarly, 75.71% (N=53) of the total respondents, cumulatively agreed that as young ladies pursuing mathematics, there were no female mathematics role models to emulate, 7.14% (N=5) neither agreed nor disagreed, and 17.15% (N=12) disagreed. On the statement "Whilst pursuing my education, I mostly face difficulties due to the abstract nature of mathematics", 17 respondents representing 24.29% responded in agreement, 29 respondents representing 41.43% were irresolute and 24 respondents representing 34.28% disagreed. Finally, in responding to the statement "As a young lady pursuing

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mathematics, my peers attribute my high performance in mathematics as a result to flirting with the tutors" 26 respondents representing 37.14% of the total respondents responded in agreement, 10 respondents representing 14.29% were neutral and 34 respondents representing 48.57% responded in disagreement.

To add strength to the quantitative data and also gain in-depth detail about the unhealthy school experiences of respondents, excerpts from the interview have been presented below. Out of the 10 interviewees, 7 indicated in their responses that they had unhealthy experience school experience. 4 of the 7 responses are presented because so 4 of them were talking about the same thing some 1 was selected. From the analysis of the interview transcript, it was disclosed that most females were afraid of pursuing mathematics due to their prior experience with how teachers teach the course from primary level. It was also unveiled that due to the way the teachers teach the subject, most females have a challenge of understanding mathematical concepts that were taught. To some of the interviewees, their teachers did not even devote extra time to do a remedial teaching to assist them fill their concept gaps. These opinions have shown how teachers' teaching approaches have contributed to mathematics dislike as well as poor grades in mathematics among females in the educational ladder.

Respondent 9 had this to say:

> *'I will never forget what happened to me in primary 6, I even have that mark to date. I was very much afraid of mathematics at the basic level because of the way my teacher used to teach it. He used to complicate things for us. And even if you tell him you don't understand, he does not go the extra mile to explain it better…hmmm, later when we perform poorly, he then gets angry and punishes us severely. So, it really made me scared of mathematics but upon reaching junior high school the story*

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changed, that mathematics teacher was splendid... he made mathematics very simple to understand and frequently related it to the natural things around us.'

Moreover, it was discovered from the analysis of the transcript that some of the teachers use discouraging words on females during mathematics class or lectures which depresses the female students from liking and pursuing mathematics. Further to these, some of the respondents reported that their teachers put up behaviours that makes it as if mathematics is difficult for females to pursue. These attitudes put up by the teachers led to some of the students describing them as horrible mathematics teachers.

Respondent 5 (a lecturer) stated that

"My terror about mathematics started at A level. I had a horrible mathematics teacher. Basically, the flaws we have in mathematics are because teachers don't teach it well. He assumes we are girls therefore; we do not need to be particularly good at A-level mathematics. My teacher behaved as if mathematics was too difficult for women to perform well."

Another Respondent 10 (an MPhil student) bitterly expressed herself this way:

'After my first year at the university, I was on the verge of leaving. I had a strong desire to stop. In my first year, I had terrible grades in both my first and second semester exams... and the discouraging words from one of my lecturers made me very frustrated and depressed... I doubted my capabilities in mathematics, and I wasn't sure if I could continue with mathematics... but my father and a few friends motivated me to stay... My father used to contact me every day to encourage me, not to give up but

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study hard.... And today, I'll say that my father has had the largest influence on my retention in the mathematics field.'

It also cropped-up from the analysis that some lectures and supervisors delayed females pursuing graduate and postgraduate from completing their project works and dissertations. Some of the supervisors gave many excuses to cover-up and intentionally delayed the candidates from completing the programme as scheduled.

Respondent 3 (a lecturer) shared her experience…

"During my masters, I spent 4 years instead of the usual 2 years. I remember we even had to go to other universities to take some of the courses… but the actual problem started when I was doing my Ph.D. My supervisor delayed me during my dissertation writing. After I was done writing my dissertation, he kept on making so many excuses when he finally had to append his signature…. he was saying I have to do more work to prove myself…but as a student I also felt that I have done enough to earn the doctorate title. So, there was a little battle here and there…"

In all, it appears that the use of poor or unrich teaching approach coupled with teachers' attitude towards teaching as well as how teachers relate with females in the mathematics classroom constituted to unhealthy school environment which accounted for the experiences that these successful female professionals had in their educational journey. The findings from the interviews validated the findings from the quantitative analysis. For instance, 75.71% from the questionnaire analysis agreed to the fact that "Whilst pursuing my education, most of my teachers applied inappropriate instructional methods during mathematics lessons."

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4.2.2 Socio-Cultural Practices and Beliefs

The number of responses of the questionnaire items with respect to respondents' experiences of socio-cultural practices and beliefs in their educational and career journey has been presented in Table 5

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Table 4.

Socio-cultural practices and beliefs

ITEMS	SA	A	N	D	SD
As a young lady growing up in the Ghanaian society, most people in my immediate environment held the perception that Mathematics is a male domain and not for females (like me).	15(21.43)	37(52.86)	13(18.57)	5(7.14)	0(0.00)
	74.29%			7.14%	
As a young lady pursuing mathematics, my father was not supportive of my desire in attaining a mathematics career.	5(7.14)	13(18.57)	17(24.29)	27(38.57)	8(11.43)
	25.71%			50.0%	
As a young lady pursuing mathematics, my mother was not supportive of my desire in attaining a mathematics career	8(11.43)	19(27.14)	17 (24.29)	19(27.14)	7(10.0)
	38.57%			37.14%	
As a young lady growing up in the Ghanaian society, most people held the perception that the woman's place is the kitchen and not to study mathematics	15(21.43)	11(15.71)	23(32.86)	18(25.71)	3(4.29)
	37.14%			30.0%	

Results from Table 4 revealed that, 74.29% (N=52) of the total respondents agreed that as young ladies growing up in the Ghanaian society, most people in their immediate environment held the perception that Mathematics is a male domain and not for females like them, 18.57% (N=13) were neutral and 7.14% (N=5) disagreed. Also, on the

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statement "As a young lady pursuing mathematics my father was not supportive of my desire in attaining a mathematics career", 18 respondents representing 25.71% responded in agreement, 17 respondents representing 24.29% neither agreed nor disagreed while 35 respondents representing 50% responded in disagreement. Similarly, in responding to the statement "As a young lady pursuing mathematics, my mother was not supportive of my desire in attaining a mathematics career", 27 respondents representing 40% of the 70 respondents were in agreement, 17 respondents were irresolute, and the remaining 26 respondents representing 37.14% responded in disagreement. Lastly, 26 respondents representing 37.14% of the total respondents agreed to the fact that most people held the perception that the woman's place is the kitchen and not to study mathematics", however, 21 respondents representing 30% responded in disagreement and 23 respondents representing 32.86% were neutral.

In addition, the analysis of the interview transcript disclosed how females were often faced with discouragement from people in the society from pursuing mathematics disciplines. The females emphasized on the existence of the societal belief that, mathematics related disciplines are too difficult for females to study therefore, only males can study it, while arts and humanities are the suitable programmes for female to pursue. Two of the respondents had this to say:

Respondent 1 (a lecturer) stated that;

> *"People still believe that mathematics is only for men since it is tough... As a result, most women are discouraged from pursuing mathematics. You know, just because I was good in both science and mathematics, I was not sure which programme to study at the university after I completed A' level. So, I contacted two male friends who were both at the university*

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(name of institution withheld) and told them about my plans to study a mathematics-related programme at the university. I was surprised about the reply of one of them, he was like "Eeeii, you are a lady ooh! the way the guys are complaining about how difficult the programme is, can you do it as a lady? You might not be able to do it.""

Respondent 2 (a lecturer) commented that:

"You know, the society has a very funny way of doing this whole career profiling, that a woman should study nursing and other biological sciences whiles the guys study the physical science and mathematics related programmes. My parents were not supportive when I gain admission to pursue statistics at the university. My mother was insisting I go and offer nursing just because I am a lady"

Also, the data showed that in some Ghanaian societies, women were discriminated against not only in the study of mathematics-related disciplines but in general education as a whole. The burden of women performing household chores, coupled with the pressure to marry early before furthering their education had been some of the experiences of females. The society has a mind-set of no matter how far a female reaches in education she comes back to the kitchen and a good skill in the kitchen is what makes her future home successful. This unveils why females in Ghanaian society are mostly engaged in household chores due to the intend duties expected from women as future wives, unlike their male-counterparts who have all the time to themselves.

Respondent 6 (a lecturer) recounted her bitter experience with her mother:

"A woman's place is the kitchen has always been the notion against women. Culturally we are made to believe that women belong to the kitchen and are to do household chores, this they think will make the

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future of a woman successful. I remember when I was growing up, anytime I get home after school… my mother used to engage me in the kitchen leaving my brothers to study or even go out to play football… if you murmur … she goes by the adage, you should know how to prepare food in order to make your future home successful."

Respondent 10 (an MPhil student) also reported that:

"My mother insisted I get married before I further my education, especially in a male-dominated field like mathematics because I'm her only daughter. She said as a woman it will be difficult for a man to approach me for marriage because of my educational status in a male-dominated field. And you know, society has the notion that women may never marry if they attained higher degrees in mathematics-related fields. Hmmm, I also remember when one of my aunties called me and was like, as a young woman, it is not right to attain qualifications higher than the man you will marry, so I should slow down"

The experiences shared by the respondents revealed that sometimes socio-cultural beliefs and practices had impacts on females in their pursuit of mathematics-related programmes and careers. The stereotypic belief about the suitability of a programme or profession based on gender is still in existence. Also, the data showed that in some Ghanaian societies, women are discriminated against not only in the study of mathematics-related disciplines but in general education as a whole. The burden of women performing household chores, coupled with the pressure to marry early before furthering their education had been some of the experiences of female mathematics professionals.

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4.2.3 Managing Multiple Roles

From the analysis of the interview transcripts, it was discovered that the task of combining motherhood with the demands of an academic work was challenging and also militated against females' mathematics career development. In pursuit of higher degrees in mathematics, most of the respondents were left with no option than to delay because of the responsibilities of motherhood.

Respondent 2 (a lecturer) had this to stay:

> *"I delayed in writing my dissertation... I had to work for additional years before I finally finished. My kids were continuously asking, "Mummy, when are you going to finish your PhD?" Combining career, family, and academic work has not been easy. Going to teach, returning home, and performing household tasks, including writing my dissertation resulted in sleepless nights... There was no such thing as rest. Balancing family, career and academic work is very difficult....*

Similar to findings of females delaying with their academic advancement in order to focus on motherhood, another interviewee shared her observation in the mathematics department among married women she was pursuing doctorate degree with.

Respondent 4 (a lecturer) had this to say

> *'For the women who are married with kids the journey has really being a tough one for them… there were people who have already spent 5 years when I was in my second year and they were still striving hard to finish… I completed with one elderly woman in my department who had delayed so much because of childbirth. Actually, some role models as well as my supervisors advised me not to marry until I finish my Ph.D. because of what was happening in the*

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department… I think when I completed, all those who were single also completed on time as compared to those who were married.'

The interview also revealed that some females found it very difficult to spent time on campus for personal studies, group discussion or even research in the library due to family duties. Any other day aside lecture day, they have to be at home catering for the family. This makes it very difficult to do more research and revise on what was taught at lectures.

Respondent 9 (an MPhil student) stated:

"I mostly go home on weekends and days we don't have lectures to perform my duties as a mother and wife. So, you hardly see me on campus. My mother sometimes come around to help with the kids… but you know the old lady cannot do all the work so I have to go and help"

It further cropped up from the analysis that though some women delay their academic advancement to focus on motherhood, others did otherwise by holding on with childbearing to focus on their academic advancement. Since the mother has to be nurturing, and the academician has to be productive and both duties are equally demanding, time consuming, and require a lot of sacrifices, one is always done at the expense of the other. An interviewee shared her experience on how she had to take a unified decision with the husband to hold on with childbearing in order to focus on pursuing her education

Respondent 5 (a lecturer) said that:

'Combining family life and academic work has not been easy…You know, at a time, after we gave birth to our two children, we decided to pause for me to continue with my Ph.D. Because we realise that I could not combine motherhood and academic life and moreover I am the kind who likes to

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discharge my duties excellently… so we decided to consider my academic advancement first, which was the initiative of my husband'

In all the study findings highlighted some sacrifices of females in order to perform their family responsibilities and also pursue their educational advancement. The female mathematics professionals unveiled their difficulties in managing multiple roles especially when they were married with children and advancing in their education. For instance, some of the females had to delay with pursuing higher degrees in order to focus on motherhood whiles others have to hold on with childbearing in order to focus on their education.

4.2.4 Financial challenges

Responses from the questionnaire items on financial challenges have been shown in Table 5.

Table 5

Financial challenges

ITEMS	SA	A	N	D	SD
As a young girl pursuing mathematics, I frequently faced financial instability which affected my interest in mathematics	7(10.0)	21(30.0)	25(35.71)	14(20.0)	3(4.29)
	40.0%			24.29%	

Findings from Table 5 indicated that 40% (N=28), 32.86% (N=25) and 24.29% (N=17) respectively responded in agreement, neutral and disagreement to the statement "As a young girl pursuing mathematics, I frequently faced financial instability which affected my interest in mathematics".

The analysis of the interview transcript revealed lack of funds as one of the challenges faced by aspiring female mathematics students. It is sometimes difficult for female to get

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financial aid in the form scholarship from their universities to pursue mathematics to the doctoral level. Some would have to rely on their basic income. Also, some female students had to break their educational journey to trade in order to get funds to continue. This is common in instances where the family is not capable of sponsoring them. Some females strive through it while others end up getting pregnant, gets married and become mothers, thus quitting their formal education entirely.

Respondent 2 (a lecturer) said;

> *"Yes, I encountered some financial challenges during my doctoral studies… I didn't get any grant or scholarship. I didn't even receive any support from the university (name of university withheld). As a result, I had to pay for everything out of my own coffers… it was my husband who paid the rest of the fees when I became financially handicap because of other demands."*

Respondent 3 (a lecturer) painfully expressed herself on how lack of funds hindered her friend from furthering her education;

> *"Poverty to me has contributed to many young ladies sacrificing their dreams of becoming mathematics professionals. My best friend in the secondary school couldn't further to read mathematics related programme even though she was one of the best maths students in our class. After completion, she was advised to work for some time to save towards furthering her education but unfortunately, she ended up getting pregnant. What pains me is, (name withheld) was made to marry the man who impregnated her and that ended her ambition of being a mathematician.*

Some respondents also revealed that due to inadequate funds, their family choose to fund the education of the males in the family at the detriment of the females. It shows that in some societies the education of the sons is given much priority than that of the females.

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Respondent 6 (a lecturer) had this to say

> *"The most difficult challenge I had, was obtaining funds for my secondary school education. When my father was laid off from his job during the revolution, I never resented my parents for choosing to provide for my brothers' education. My father got laid off from his job during my O' level... As a result, the finances in the house were insufficient to cover both home maintenance and our education... My parents forced me to stay at home for a few months while my brothers went to school... I hope you are aware of the Ghanaian belief that values male education over female education..."*

In all, the data indicated that the low economic status of some parents affected most females in their pursuit of degrees in mathematics related careers. There were instances where families gave priority to the education of their sons than their daughters when there were inadequate funds. In addition, some females had to break their educational journey to trade in order to get funds to continue, while other females had to rely on their basic income to further their education since there was no form of scholarship.

4.3 Research question 2

What facilitated the resilience of successful female mathematics professionals in the field of mathematics?

Respondents responded to a questionnaire and semi-structured interview questions to share the factors of resilience that they employed to counter the obstacles encountered during their educational and career journey. Based on the responses of the questionnaires and interviewees two major themes were deduced: internal and external resilience factors.

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4.3.1 Internal Factors

The number of respondents response for each item is shown in Table 6.

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Table 6.

Internal factors that facilitated resilience of respondents

ITEMS	A	N	D
My frequent high-Performance during mathematics lessons facilitated my resilience in pursuing a mathematics career	58** (82.86%)	10 (14.28%)	2* (2.86%)
My strong confidence level in performing a mathematics task facilitated my resilience to pursue a mathematics profession	49** (70.0%)	16 (22.86%)	5* (7.14%)
As a young lady growing up, my great passion in attaining a mathematics career facilitated my resilience to pursue mathematics	49** (70.0%)	19 (27.14%)	2* (2.86%)
My resilience in pursuing a mathematics career was facilitated by my high level of self-efficacy in mathematical achievements	55** (78.57%)	14 (20.0%)	1* (1.43%)
I will attribute my resilience in pursuing a mathematics career to perseverance and persistence	48** (68.57%)	19 (27.14%)	3* (4.29%)
My mathematical curiosity and wide interest in mathematics as a subject facilitated my resilience to pursue mathematics to the highest level	42** (60.0%)	26 (37.14%)	2* (2.86%)
As a young lady, I had early aspirations of becoming a mathematics professional	49** (70.0%)	8 (11.43%)	13* (18.57%)

****Sum and percentage include Strongly Agree and Agree**
*** Sum and percentage include Strongly Disagree and Disagree**

Findings from Table 6 revealed that, 58 respondents representing 82.86% responded in agreement to the statement" My frequent high-performance during mathematics lessons facilitated my resilience in pursuing a mathematics career", 10 respondents representing 14.28% responded neutral, however, 2 respondents representing 2.86% disagreed to the statement. Similarly, in responding to the statement "My strong confidence level in performing a mathematics task facilitated my resilience to pursue a mathematics profession", 70% (N=49) cumulatively responded in agreement, 22.86% (N=16) neither

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agreed nor disagreed, while 7.14%(N=5) responded in disagreement. Also, 49 respondents representing 70%, 19 respondents representing 27.14% and 2 respondents representing 2.86% respectively responded in agreement, neutral and disagreement to the statement "As a young lady growing up, my great passion in attaining a mathematics career facilitated my resilience to pursue mathematics". Results from Table 6 further revealed that the majority of the respondents, thus 55 respondents representing 78.57% of the total respondents were in agreement with the statement "My resilience in pursuing a mathematics career was facilitated by my high level of self-efficacy in mathematical achievements", while 14 respondents representing 20% were irresolute, only 1 respondent representing 1.43% responded in disagreement. Similarly, on the statement "I will attribute my resilience in pursuing a mathematics career to perseverance and persistence", 48 respondents representing 68.57%, 26 respondents representing 37.14% and 3 respondents representing 2.86%, responded respectively in agreement, neutral and in disagreement. Moreso, from the Table 6, in responding to the statement "My mathematical curiosity and wide interest in mathematics as a subject facilitated my resilience to pursue mathematics to the highest level", 60% (N=42), 37.14% (N=26) and 2.86% (N=2), respectively responded in agreement, neutral and in disagreement. Finally, 49 respondents representing 70% of the respondents agreed to the fact that their early aspirations of becoming a mathematics professional facilitated their resilience to pursue higher degrees in mathematics, however, 13 respondents representing 18.57% were in disagreement and 8 respondents representing 11.43% were neutral

Over the course of the interviews, it became apparent that there were certain internal resilience factors that were common amongst the respondents in this study. Internal factors such as mathematical self-efficacy, high aptitude, determination and confidence

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in mathematics are some of the common factors that have contributed to respondents' resilience and sustainability in the mathematics discipline.

4.3.1.1 Mathematical Self-Efficacy

The analysis of the interview transcript revealed self-efficacy and mathematical competence as the main backbones of females who strive through the journey of becoming mathematics professionals. Some female students indicated their resilience as being able to tackle challenging mathematical questions and solving them. Obtaining the solution alone motivated and inspired them to yearn for higher and tougher mathematical challenges. This experience explains how female's self-efficacy belief (mastery experience) played a mediational role in that they serve as filters between their prior achievements and subsequent achievements. In order words, females relied on their mastery experience to influence their future achievements.

Respondent 8 (an MPhil student) had this to say:

> *'Throughout my primary and secondary education, I have achieved excellent grades in all subjects although my passion leaned more towards mathematics. Personally, I enjoyed being challenged, that is, doing what other people think it's too difficult (like mathematics) just because there are fewer females reading it. I did find much pleasure in solving tough and challenging questions especially the mathematical proofs. And you know, it's like I gain a personal satisfaction when I get it right. So, the capability and efficacy were there right from the onset."*

In addition to mastery experience, the study further discovered vicarious experience and social messages or verbal persuasions as critical sources for the development and maintenance of females' mathematical self-efficacy beliefs. Female students indicated

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their vicarious experience as getting influence from role models (though not in physical contact) by reading about their achievements in novels. Also, with respect to verbal persuasions, females recalled the frequent encouragements and commendations from individuals such as parents and teachers which increased their efficacy belief and persistence in the mathematics discipline.

Respondent 3 (a lecturer) stated that:

"Mathematics has an interesting factor to it and that's what made me stay motivated. Though I was a good student in all subjects, when it comes to maths, I was exceptional. And it was a great prestige when you are the best student getting most of the prizes in mathematics and science subjects. Despite the fact that some of my teachers mostly made comments that imply that males can easily excel in mathematics than females, they however encouraged me to carry on with mathematics and science subjects because, I was very good and they trusted in me."

Respondent 4 (a lecturer) said that:

'I really enjoyed reading novels comprising of the inventions of some scientist and mathematicians. Their inventions made me embrace the excitement of contributing something significant to aid humanity. I remember reading about the first woman mathematician which enacted my efficacy belief and self-esteem in mathematics and science. Also, I think my father being a teacher helped me a lot, he provided me with most of such novels in my small library. That exposure made me develop a deep love and interest in science and mathematics subjects and I always knew that one day, I would have either a science or mathematics related career.'

In summary, mathematical self-efficacy as an internal resilience factor was found to provide females with the tenacity to excel within the mathematics field. The data revealed that females had high self-efficacy belief regarding their competence, problem solving

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abilities and excellent performance on a given mathematics task. Females made reference to their mastery experience, vicarious experience and verbal persuasions as major pillars of self-efficacy which increased their resilience and persistence in the mathematics field. In addition, female students tried their maximum best to change the status quo. The mere fact that there were few females studying mathematics to the higher level inspired these females to do more in order to change the narrative.

4.3.1.2 Self-Confidence and Determination

From the analysis of the interview transcript, self-confidence and determination was identified as an ultimate internal factor influencing the achievement behaviour at both early and later stages of females' mathematics educational journey. One of the underlying mantras of the respondents was that giving up was not an option, hence they developed a spirit of determination and perseverance. Thus, the females were determined not to let obstacles deter them from accomplishing success in the mathematics field. Three of the respondents had this to say:

Respondent 4 (a lecturer) stated that:

> *"For me it has always been determination... if you are determined and passionate about your vision or chosen career in life, no matter the difficulties you are facing or what people are saying, you will never give up. I had to forego my former profession though it was very lucrative and my superiors did not want me to leave. They even increased my salary so I will stay but I had to follow my passion so I left to pursue my PHD in the mathematics field. Actually, there is nothing more fulfilling in life than doing the job that you really enjoy."*

Respondent 2 (a lecturer) had this to say:

> *"I think my career life is all about dreaming big, taking the risk and believing in yourself... surrounded by the cultural belief rooted in my mother, I had to remain*

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tough at some point and stick to what I want to become… I was naturally very good in mathematics, so much that I was always the point of reference for my teachers. I wanted to be in the mathematics related field but my mother was saying nursing will be best for me as a female, but nursing was not what I wanted. You know, I always say that everything is possible for anyone who believe she can achieve something. If someone had attained that height or profession, even if he is a male, you can also attain it as a female.

Respondent 7 (an MPhil student) stated that

"Mathematics has always been a subject that I had so much confidence in, since I was in basic school. I was a brilliant student and I used most of my break time to teach my colleagues… most of my mates used to come to me to assist them by explaining some concepts taught in class to them… that confidence and determination to excel in mathematics has remained the same. And because of my outstanding performance, my lecturers mostly encourage me."

Females emphasized on their self-confidence and determination to succeed as powerful motivators that affected the choices they made, the effort and persistence they put forth, and the resilience they show in overcoming the obstacles in their educational journey. The respondents explicitly stated that they were not going to quit or change their career path, because they felt destined to be in the mathematics field. That is not to say that they did not have obstacles or challenges that made them ponder the option to give up, however, respondents inherently emphasized that their confidence in their mathematics ability motivated them to persist through obstacles faced.

4.3.2 External Factors

The involvement of females in co-curricular and extra-curricular activities (such as field trips, mathematics clubs and mathematics quizzes) drive and facilitated females' interest

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in mathematics at the early-stage. It further continued with females pursuing elective mathematics at the senior high school to pursuing a mathematics degree, then ultimately securing a mathematics profession. The number of respondents responses to each questionnaire item is shown in Table 7.

Table 7.

External factors that facilitated resilience of respondents

ITEMS	A	N	D
the motivation from my parents that mathematics is applied in everyday life facilitated my resilience to pursue a mathematics career	54** (77.14%)	7 (10.0%)	9* (12.86%)
my participation in mathematics extra-curricular activities facilitated my resilience to attain a mathematics profession	51** (72.86%)	9 (12.86%)	10* (14.28%)
my female mathematics teacher served as a role model for me to pursue a mathematics career.	12** (17.14%)	0 (0.00%)	58** (82.86%)
my teacher made the abstract nature of mathematics very practical and real.	38** (54.29%)	3 (4.29%)	29* (41.42%)
as a young lady pursuing math the frequent praises from my immediate society facilitated my resilience to attain a math profession	40** (57.14%)	28 (40.0%)	2* (2.86%)
my parent's mathematics related profession steered me towards attaining a mathematics career	43** (61.43%)	0 (0.0%)	27* (38.57%)

****Sum and percentage include Strongly Agree and Agree**
*** Sum and percentage include Strongly Disagree and Disagree**

Results from Table 7 revealed that 77.14% (N= 54) cumulatively agreed to the fact that, the motivation from their parents that mathematics is applied in everyday life facilitated their resilience to pursue a mathematics career, however, 12.86% (N=9) disagreed and the remaining 10% (N=7) responded neutral. Moreover, the Table 7 showed that 51 respondents representing 72.86%, 9 respondents representing 12.86% and 10 respondents representing 14.28% of the total respondents were in agreement, neutral and in disagreement respectively to the statement "My participation in mathematics extra-curricular activities facilitated my resilience to attain a mathematics profession".

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Similarly, responses on the statement "My female mathematics teacher served as a role model for me to pursue a mathematics career" showed that only 17.14% (N=12) of the total respondents were in agreement, with no one being irresolute and majority of the respondents, thus 82.86% (N=58) disagreeing to the statement. This clearly indicates the lack of female mathematics role models in the various schools. Also, data from Table 7 revealed that 54.29% (N=38) of the total respondents agreed to the fact that their teachers made the abstract nature of mathematics very practical and real, whereas 2.29 (N=3) responded neutral, 41.42% (N=29) disagreed. Moreso, 40 respondents representing 57.14% responded in agreement to the statement "As a young lady pursuing mathematics the frequent praises from my immediate society facilitated my resilience to attain a mathematics profession", 28 respondents representing 40.0% of the total respondents were neutral and the remaining 2 respondents representing 2.86% disagreed to the statement. Lastly, 43 respondents representing 61.43% of the total respondents agreed that their parent's mathematics related profession steered them towards attaining a mathematics career, however, 27 respondents representing 38.57% disagreed to the statement and no one was irresolute.

To add strength to the questionnaire results and also gain an in-depth detail about the external factors that facilitated resilience of respondents in a male dominated discipline (like mathematics), excerpts from the interview have been presented below. The study found that early exposure and active participation of females in mathematics extra-curricular and co-curricular activities at a very young age was key in enhancing girls' competence in identifying themselves as future mathematics educators and scientists. The data discovered extra- curricular activities like mathematics field trips where nature is associated to mathematical concepts.

Respondent 1 (a lecturer) had this to say:

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"I loved mathematics just because of the exposure and interactions with real life objects through most field trips organized in the basic school. The exposure made it easy to understand some mathematical concepts and effortlessly figure out most geometric patterns and relationships. The knowledge gain through those field trips made me gain some sort of confidence and enthusiasm when it comes to mathematics… knowing well that, everything surrounding us is made-up of mathematical concepts."

It was further disclosed that the organization of mathematics quiz and competitions as well as programmes like "solve and win" by some institutions for girls with attractive motivational packages for those who excel was instrumental in promoting resilience and retention of females in mathematics disciplines. The respondents indicated that getting the chance to represent their schools in mathematics quizzes and wining the competition was enough motivation for them in increasing their interest in mathematics. Two of the respondents shared their views:

Respondent 4 (a lecturer) said that:

"I excelled in mathematics throughout my primary school and secondary school years. I remember we used to get prizes from the Junior Graphics. Junior graphic Ghana used to post mathematics questions, which one had to answer and send in order to win the prize. This aroused my interest in mathematics and gave me the confidence to pursue it further. So, most of my SSS classmates are not surprised that I studied mathematics to the higher level; in fact, a greater number of them are not even surprised I teach mathematics now."

Respondent 8 (an MPhil student) commented that:

"Well, right from a very young age I have always done exceptionally well with my academics. I used to represent my basic school in the inter-schools Science

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and Maths Quiz competition. Most often, I am the only girl among the guys to go for the trophy. So, that joy and passion for mathematics has always been there.

Findings from the study discovered that the active participation of females in co-curricular activities (e.g., mathematics clubs and mathematics inter-schools' quizzes) and exposure to real-world learning opportunities through extra-curricular activities (mathematics field trips) increased females' confidence and resilience in mathematics. The study further disclosed that the involvement of female students in outreach programmes and out-of-school mathematics related activities facilitated the development of female students' efficacy in mathematics.

4.4. Research question 3

What support systems influence the success of female mathematics professionals?

The questionnaires and interview guide addressed the support systems that influenced the success of the respondents during their educational and career journeys. Responses from interviewees and questionnaires on various support systems that influenced respondents' success revealed the following sub-themes: Family Support, Role models, School support, peer support and scholarships.

4.4.1 Family Support

Responses from the questionnaire items on family support have been shown in Table 8

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Table 8

Family support factors that influence the success of respondents

ITEMS	A n%	N n%	D n%
My parents provided me with relevant materials and resources needed for learning and attaining a mathematics profession	50** (71.4%)	5 (7.2%)	15* (21.4%)
My parents provided me with extra tuition at home for my great achievement in mathematics	44** (62.8%)	3 (4.3%)	23* (32.9%)
As a young lady, my parents took me to mathematics and science museums that steered my interest in mathematics	15** (21.4%)	19 (27.2%)	36* (51.4%)
My mother had always supported my desire to pursue and attain a mathematics profession	36** (51.4%)	10 (14.3%)	24* (34.3%)
My father had always supported my passion to pursue and attain a mathematics profession	49** (70.0%)	19 (27.1%)	2* (2.9%)
I experience countless and diverse support from my siblings whiles pursuing my education	54** (77.1%)	13 (18.6%)	3* (4.3%)
As a young lady, my parents provided me with tinker toys which created my desire to pursue mathematics	34** (48.6%)	10 (14.3%)	26* (37.1%)

****Sum and percentage include Strongly Agree and Agree**

*** Sum and percentage include Strongly Disagree and Disagree**

Results from Table 8 indicated that 50 respondents representing 71.4% of the total respondents cumulatively agreed to the fact that their parents provided them with relevant materials and resources needed for learning and attaining a mathematics profession", 5 respondents representing 7.2% responded neutral and the remaining 15 respondents representing 21.4% disagreed. Also, in responding to the statement "My parents provided me with extra tuition at home for my great achievement in mathematics ", 44 of the respondents representing 62.8%, 3 respondents representing 4.3% and 23 respondents representing 32.9% responded in agreement, neutral, and disagreement respectively. Similarly, 15 respondents representing 21.4%, agreed to the fact that their parents took them to mathematics and science museums that steered their

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interest in mathematics, however, 36 respondents representing 51.4% responded in disagreement and 19 respondents representing 27.1% neither agreed nor disagreed. Moreso, data from Table 8 revealed that 51.4% (N=49) responded in agreement that their mother had always supported their desire to pursue and attain a mathematics profession, but, 34.3% (N=24) disagreed and 14.3% (N=10) were irresolute. Moreover, in responding to the statement "My father had always supported my passion to pursue and attain a mathematics profession", 49 respondents representing 70% of the total respondents were in agreement, whereas 19 respondents representing 27.1% responded neutral, the remaining 2 respondents representing 2.9% disagreed. Furthermore, 54 respondents representing 77.1% of the total respondents indicated that they experienced countless and diverse support from their siblings whiles pursuing their education, however, 3 respondents representing 4.3% disagreed and 13 respondents representing 18.6% neither agreed nor disagreed. Finally, results from the Table 8 revealed that in responding to the statement "As a young lady, my parents provided me with tinker toys which created my desire to pursue mathematics" 34 respondents representing 48.6% agreed, 10 respondents representing 14.3% were neutral, while the remaining 26 respondents representing 37.1% disagreed.

In addition to the findings of the questionnaire, excerpts from the interview have been presented below.

From the analysis of the interview transcript, it was disclosed that fathers mostly support their daughter's choice of mathematics profession. Their fathers created a conducive learning environment and also was willing to sacrifice in order to support females learning of mathematics. There were instances where their fathers provided home tuition for their daughters, which made them develop a positive attitude and interest in the subject.

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Respondent 7 (an MPhil student) had this to say:

> *My pursuit of a mathematics profession is mainly through the support of my father. He was so passionate about the sciences and encouraged all his children to pursue either a science or a mathematics programme. In fact, it was a must that we all choose science as a programme of study at the SHS. He was also very supportive and always created a positive impression of being in the sciences. My dad used to provide extra tuition for us right after school, explaining most of the science and math concepts to the best of our understanding. And he made sure we had ample time to study and practice.*

The study also found that though respondents parents were not educated nor worked in any of the STEM related professions, they held less stereotypical belief about their daughter's mathematical career attainment. One interviewee indicated how her father pulled his resources together to help her to successfully attain a profession in the mathematics field.

Respondent 8 (an MPhil student) had this to say

> *Though both parents were not elite, they however, prioritize excellent education for me. My father was a farmer in the village who was striving so hard for the education of his children… right from my basic school to secondary school, he paid my teachers to provide private tuition for me after school, particularly in mathematics and science…he even asked me to get private tuition when I got to university, the reason being that he has heard mathematics at the university is difficult. … my father really invested so much in me (sighs) and I did not fail him either … today if I go to the village, he introduces me to people saying this is my daughter studying Mathematics at the university. He is very proud of me.*

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The study identified family support as an influential factor which help them to successfully manoeuvre their ways to gainfully attain a profession in the mathematics field. Family support comes in diverse ways; leveraging resources, providing words of encouragement, and providing extra and private tuition to their female children. Most of the respondents identified and described their fathers as the most important person who guided and assisted them to navigate the complex pathway of the mathematics discipline and emerge successful.

4.4.1.1 Spouse Support

Strong family support from spouses (the men) was essential for the success of the married woman in pursuit of mathematical higher degrees. From the analysis of the transcript, it was disclosed that most spouses were supportive of their wives to pursue higher mathematical degrees. And the men were available and ready to help whenever their assistance was needed especially with home management. In a patriarchal society like Ghana where by the responsibility of home management is culturally seen as feminine or solely the wife's duty, the females described their spouses who aided them with their domestic chores in order for them to advance in their career as blessings and a gift from God.

Respondent 1 (a lecturer) had this to say:

> *One thing that made things easier for me was my support system, who was primarily my husband. My husband has always been the reason why I got through with my PHD when it became very challenging. You know, when the need aroused for me to attend an important conference outside Ghana, I had to leave my fourteen months old baby with my husband… Although people criticize me for leaving the baby behind with his father, my husband was very supportive and gladly helped.*

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It was also unveiled in the analysis of the study that apart from assisting with domestic chores which was culturally seen as the wife's duty, some spouses further aided with the financing of their wife's education.

Respondent 2 (a lecturer) had this to say

> *I received diverse support from my husband. He helped in the payment of my school fees when I was not awarded any grant by the university and also help with the responsibilities at home. When counting my blessings, I count my husband as one of my blessings, because some of my colleagues encountered otherwise.*

Another respondent also emphasized on how her husband was very instrumental in the writing of her dissertation because he was ahead of her in the same field. She recalled how they both had sleepless night in order to get the work done on time.

Respondent 5 (a lecturer) expressed herself as:

> *My husband took me under his wing since we are both in the same field. He was my pillar when I was writing my dissertation. I remember we both had sleepless nights just to get my work done on time. Supporting my potential was very beneficial to me. He mostly encouraged me never to give up.*

From the analysis of the data each of the females recalled unique and diverse support they receive from their spouses which was essential to them as married woman with multiple roles pursuing higher mathematical degrees. Some of the respondents' descriptions of spousal support included: a partner who was willing to care for their baby; academic support and encouragement from their spouse coupled with the financing of their education.

4.4.2. Role Models

Role models play a vital role in every career one chooses to pursue. Despite the challenges females go through, the aid of role models kept them pushing on toward the

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goal of attaining a mathematics profession. Females recalled the opportunity given them to partake in programmes like STEM clinic which was geared towards motivating and guiding females to cultivate the interest in the STEM field.

Respondent 3 (a lecturer) shared her experience:

> *I had the opportunity to participate in a STEM clinic at JHS and the exposure was great. I remember in my district the coordinator was a male and we did not have female role models in these areas to interact with us during the STEM clinic meetings. The concept of mentoring us as girls in the STEM clinic was motivating. We only had a female facilitator once a while. Though it was encouraging seeing a woman in mathematics field, she wasn't from our district. Personally, I think the challenges we faced in our district as STEM clinic girls motivated me to study mathematics to the higher level, to serve as a role model to the young girls in my district.*

Aside getting in contact with female role models in schools, some females indicated the privileged to have family members who worked in STEM fields who served as precedent for them to follow. Though most of them were males, having such family members in the STEM field challenge the female to also aspire to get into STEM field though as a female.

Respondent 10 (an MPhil student) expressed herself as:

> *I came from a family full of people working in the sciences; my uncle was a renowned engineer, and my dad is a lab technician. Though they serve as role models and intrigued my interest in the sciences, they were all males…. (smiles)… so I wanted to break the record and be the first female in my family to attain a profession in the sciences or mathematics field. Hence, I just followed*

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along in their footsteps through their guidance and advice and that definitely helped make my decision easier.

It also cropped up from the study analysis that some females were also privileged to have met female mathematics teachers who mentored them along the path to success. These female mathematics teachers among other things organized girls club meetings during which the girls share their experiences, anxieties, fears and their success in the field. Through these, the girls get motivated and inspired to push forward towards the attainment of a career in mathematics.

Respondent 7 (an MPhil student) had this to say

It was up until tertiary that for once, I had an encounter with a female teaching mathematics. She supported and motivated most of the female students in the department. She used to organise girls club meetings in the mathematics department where we share our struggles and difficulties as females. Personally, she was my role model and inspirer. I was mostly fascinated with the confidence with which she taught us mathematics at the tertiary level.

Significant among the mentoring relationships that emerged in the study were organised programmes like STEM clinic and some family members and teachers who served as role models. Although most of the females recounted bitter experiences of not having enough female role models, they however appreciate the mentoring provided to them by their male mentors. The study further emphasized that the exposure of females in mathematics fields to role models provided positive opportunities for young girls to connect their interest and be successful in mathematics fields.

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4.4.3 School Support Factors

The encouragement and the conducive classroom environment provided by some teachers played a pivotal role in the lives of females from basic school experiences, throughout high school, and continued into their professional experiences as well. The outpouring of unconditional support and guidance provided the foundation the respondents needed to be successful. Responses from the questionnaire items have been shown in Table 9

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Table 9

School support factors that influence success of respondents

ITEMS	A	N	D
My school created a conducive mathematics learning environment for me.	46** (65.71%)	5 (7.15%)	19* (27.14%)
My school provided me with relevant materials and resources needed for learning and attaining a mathematics profession	44** (62.86%)	8 (11.43%)	18* (25.71%)
My school counsellors often coach me in various careers in mathematics.	20** (28.57%)	4 (5.71%)	46* (65.72%)
My peers supported me through peer learning whilst pursuing my mathematic education	53** (75.71%)	10 (14.29%)	7* (10.00%)
My school made provision of scholarships for females pursuing mathematics	43** (61.43%)	0 (0.00%)	27* (38.57%)
My teacher created opportunities for learning and practice of mathematics inside and outside the classroom	44** 62.86%	10 14.29%	16* 22.86%
It was my teacher who encourage and fueled my confidence to pursue mathematics profession	56** 80.00%	9 12.86%	5* 7.14%
The frequent career guidance sessions organize in my school steered my passion for a mathematics career	48** 68.57%	10 14.29%	12* 17.14%
My school created the avenue for me to have mentoring and interactions with mathematics female role models	15** 21.43%	5 7.14%	50* 71.43%

****Sum and percentage include Strongly Agree and Agree**

*** Sum and percentage include Strongly Disagree and Disagree**

Results from Table 9 revealed that 46 respondents representing 65.71% agreed to the fact that their schools created a conducive mathematics learning environment for them,

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however 19 respondents representing 27.14% disagreed and the remaining 5 respondents representing 7.14% were neutral. Also, in responding to the statement "My school provided me with relevant materials and resources needed for learning and attaining a mathematics profession", 44 respondents representing 62.86% agreed, whereas 8 respondents representing 11.43% neither agreed nor disagreed, the remaining 18 respondents representing 25.71% disagreed. Similarly, only 20 respondents representing 28.57% of the total respondents agreed to item that their school counsellors often coach them in various careers in mathematics, majority of the respondents (thus 46 respondents representing 65.72% of the total respondents) disagreed and the remaining 4 respondents representing 5.71% responded neutral. Moreso, data from Table 9 indicated that majority of the respondents, thus 75.71% (N=53) of the total respondents agreed to the fact that their peers supported them through peer learning whilst pursuing their mathematics education", but 10% (N=7) disagreed and 14.29% (N=10) were irresolute. Similarly, findings from Table 9 indicated that 43 of the total respondents representing 61.43% agreed in responding to the statement "My school made provision of scholarship for females pursuing mathematics" but, 27 respondents representing 38.57% disagreed and no one was irresolute. Also, 44 respondents representing 62.86%, responded in agreement that their teachers created opportunities for learning and practice of mathematics inside and outside the classroom, however, 16 respondents representing 22.86% disagreed, and 10 respondents representing 14.29% neither agreed nor disagreed. Furthermore, in responding to the statement "It was my teacher who encourage and fuelled my confidence to pursue mathematics profession" majority of the respondents, thus 80% (N= 56) agreed, whiles 12.86% (N=9) responded neutral and 7.14% (N=5) disagreed. In addition, 48 respondents representing 68.57%, responded in agreement that the frequent career guidance sessions organize in their

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schools steered their passion for a mathematics career" whereas, 10 respondents representing 14.29% responded neutral and 12 respondents representing 17.14% disagreed. Finally, results from Table 9 revealed that in responding to the statement "My school created the avenue for me to have mentoring and interactions with mathematics female role models" 15 of the 70 respondents representing 21.43% responded in agreement, 5 respondents representing 7.14% responded neutral and the majority of the respondents, thus, 50 respondents representing 71.43% disagreed.

To add strength to the quantitative data, and to ensure thorough exploration of the school support factors that influence respondents' success in the mathematics field, excerpts from the interview have been presented below. The analysis of the interview transcript revealed that support from the school cushioned most females in their quest to pursue a career in mathematics. Some teachers intentionally mentored these young ones to make mathematics as loving as possible. Some teachers even organized remedial class in order to support and direct females on their path in the mathematics profession.

Respondent 7 (an MPhil student) had this to say:

> *It was my secondary school teacher who supported and guided me on this mathematics path. In my secondary school, one had the option to choose either biology or elective mathematics as a science student. Though I was good at mathematics, I followed friends and chose biology. So elective mathematics was not part of my electives and you know it's very essential if one want to pursue a mathematics related degree. But thanks to my core mathematics teacher, who counselled and shaped my career path. He gave me the support and opportunity by organising private tuition for me till I registered and wrote the Elective mathematics Nov-Dec exams.*

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Beyond organizing remedials to help direct the path of females in the mathematics field, some other teachers took it upon themselves to fund the education of some females. An interviewee reported that she owes her career achievement to a teacher who came in just at the right time to her rescue… Females could be at the verge of either switching from their mathematics path or quitting education entirely due to lack of funds in their education. However, some teachers do come in and rescue them.

Respondent 6 (a lecturer) shared her experience:

> *After my dad was laid off at work, it was one of my O' level teachers who provided me with financial assistance till I completed A' level. Though he is no more to see the result of his kindness. I will never forget him because, he is the backbone of who I am today. This teacher liked me a lot because of my high performance in mathematics. I was like a daughter to him.*

It also cropped up that, some schools are well equipped with laboratories, teaching and learning materials, competent teachers and enabling environment that makes mathematics more enjoyable. Females who found themselves in such school seize the opportunity to study mathematics to the higher levels.

Respondent 4 (a lecturer) said this:

> *I attended a Montessori school, so right from the basic level, mathematics was a subject I really enjoyed. I hope you know what I mean by a Montessori school as at that time (a well-furbish school), we even had a science laboratory. So, teachers used the appropriate teaching and learning materials whenever they are teaching. Therefore, mathematics as a subject was practical and very simple to understand. This helped me to develop interest in the mathematics right from the basic level.*

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Moreover, some teachers made mathematics enjoyable with rewards systems. Teachers who gave mathematical problems to students to work on and later gave parcels to the winners, motivated female students to strive hard and learn more.

Respondent 9 (an MPhil student) had this to say:

> *I had a fantastic mathematics teacher who encouraged me to pursue mathematics at the university. I remember he mostly come to class with some mathematics riddles for us to solve and he had a parcel for anyone who gets it correct, so there was some kind of competition in the class as to who solves it first and takes the prize… mathematics became fun and friendly…this really motivated me that I spent a good part of my nights on solving mathematics problems. Also, I derive some kind of satisfaction when I finally figure out the answer to some extremely tough exercises though sometimes it spanned through a long time.*

A conducive school environment as well as support from teachers, especially those teaching mathematics at lower levels of education was identified in the study as an important factor that enabled females to successfully attain a mathematics career. Most females revealed that the support from teachers was mainly in the form of encouragement, funding of their education, offering remedial teaching, using reward systems as motivation and also letting females know that they had the potential to succeed in the mathematics field.

4.4.3.1. Peer Support

Data gathered from this study revealed that support from colleagues undertaking the same programme was key in enabling females to be successful in their mathematics educational journey. Most of the respondents sought help with concepts that were conceptually difficult to them through peer support activities like peer tutoring and study

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groups. It was also disclosed that most peers through study group discussions devote enough time to each member for better understanding of the concept. An interviewee pointed out that study group discussions *was extremely beneficial to her during both her undergraduate and postgraduate studies.*

Respondent 10 (an MPhil student) had this to say:

> *Fortunately, I joined a study group during my second year, which helped me get back on my feet and rekindled my strength. During group meetings, my colleagues spend a significant amount of time solving and discussing mathematical problems to ensure that every member understands the concepts well. So, for me, peer support has been extremely beneficial during both my undergraduate and postgraduate studies. Let me say that the frequent study group discussions helped me perform well in subsequent semesters, giving me the confidence and courage to pursue my second degree.*

Another respondent made mention of an affectionate peer climate which increase her confidence and sense of belonging in the mathematics classroom. She also reported of her colleague rendering help through peer tutoring

Respondent 3 (a lecturer) said that:

> *Because I was the only lady in the class, I always had that strange feeling. Though I was never victimized by my male colleagues, adjusting was a little bit of a challenge. But eventually I got closer to one of my male colleagues, who was more of a study partner. (Name withheld) was one brilliant student who used to explain most of those abstract concepts and theories to me.*

Most of the respondent generally made more favourable comment about support and encouragement they receive from their peers. Notably, support from respondents' male colleagues built a sense of belonging that increased the level of confidence in their

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mathematical abilities and ultimately resulted in respondents' retention in the mathematics discipline.

4.4.4 Scholarships

From the analysis of the interview transcript, it was unveiled that scholarship was a crucial facilitator for the success of females in the mathematics profession. The study found that awarding of scholarships by governmental and non-governmental institutions had a large positive effect on the retention of females in the mathematics fields.

Respondent 9 (an MPhil student) had this to say:

> *"Of course, I am a product of the Vodafone Ghana Foundation scholarship scheme. It was a scholarship for females offering STM (Science, Technology and Mathematics) programmes in (name of institution withheld). The scholarship was mainly given to females with high academic grades but have low economic status. Fortunately, this scholarship arrived on time and took away the burden of thinking about how to pay my second-year school fees."*

Another Respondent 8 (an MPhil student) also stated that:

> *"I have been incredibly privileged to enjoy most scholarship schemes climbing my educational ladder. During undergraduate I was on the GNPC (Ghana National Petroleum Corporation) scholarship scheme. And also, during my second degree I obtained an educational scholarship from my district."*

Other respondents made mention of scholarships awarded by international organisations which aided their smooth transition from one stage of their education to the next level.

Respondent 5 (a lecturer) had this to say:

> *I had a scholarship from an international organisation (name of institution withheld) for both masters and PHD. The scholarship was for females in STEM*

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and I quickly grab that opportunity. So, I think for females in the sciences, there are a lot of scholarships available.

Respondent 3 (a lecturer) commented that:

During my national service as a teaching assistant. One of my lecturers introduced me to the AIMS Masters Programmes, (Masters in Mathematical Sciences). Not AIMS-Ghana. Sincerely speaking, I was very lucky to get that scholarship because it was a full scholarship covering accommodation, tuition and travel expenses.

Support in terms of financial resources was highlighted by respondents as a significant factor in ensuring that females were successful in their mathematics career. Financial support was mostly in form of payment of school fees for respondents at one stage of their education to ensure their smooth transition to the next level. At the university level, scholarships offered by governmental and non-governmental agencies to females particularly in STEM programmes were vital in facilitating a successful completion of respondents STEM studies. The study found that scholarships enhanced the achievement rate and promoted access and persistence of female students in STEM programmes.

4.5 Research question 4

What is the relationship between support system and females' mathematical resilience?

The last research question found out the relationship between support systems (such as school support and family support) and females' resilience in mathematics. In order to answer research question four, Pearson product moment correlation analysis was conducted. The responses on items in section C and section D of the questionnaire instrument (see Appendix A) was used in the analysis. A null (H_0) and alternative (H1) hypotheses were formulated and tested at $\alpha = 0.05$

H_0: there is no relationship between support systems and resilience in mathematics

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H_1: there is a relationship between support systems and resilience in mathematics

Before the Pearson's product-moment correlation coefficients were calculated, the constructs were subjected to the following assumptions

- the constructs (family support, school support and mathematical resilience) were measured on the interval scale; thus, they met the level of measurement assumption.
- to achieve normal distribution of the data, each variable was determined for normality separately using a histogram and the curve in SPSS (see Appendix E).
- Linearity assumption was tested using a scatter plot and it showed that the linear relationship between the constructs is approximately linear. The scatter plot was done to check if the variables; each support systems and resilience in mathematics were linearly related (see Appendix D).
- There are no outliers among the data for each construct which signifies that the outlier assumption was met (see Appendix D).

The Pearson Product-Moment Correlation coefficients between support systems and females' resilience in mathematics are shown in Table 10.

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Table 10

Pearson product-moment correlations among support systems and females' resilience in mathematics.

		Mean	Standard deviation	FS	SS	MR
FS	Pearson Correlation	31.27	4.824	1		
SS	Pearson Correlation	42.24	4.868	0.863**	1	
	Sig. (2-tailed)			0.000		
MR	Pearson Correlation	48.98	2.867	0.622**	0.653**	1
	Sig. (2-tailed)			0.000	0.000	

**** Correlation is significant at the 0.01 level (2-tailed).**

*** Family Support (FS), School Support (SS), Mathematical Resilience (MR)**

The result in Table 10 indicated that there was statistically significant positive correlation ($r = .622$) between family support system and females' mathematical resilience. Additionally, there was a strong positive correlation ($r = .653$) between school support system and females' mathematical resilience (see Table 10). Also from Table 10, The family support system showed a mean of 31.27 and standard deviation of 4.824. Similarly, the school support system indicated a mean of 42.24 and standard deviation of 4.868 (see Table 10). Females' mathematical resilience also showed a mean of 48.98 and standard deviation of 2.867. Moreover, from Table 10 the significance value (sig.) = 0.000 is less than the usual rejection threshold value of 0.05 (i.e., $p < 0.05$). This suggests that there exists a significant positive relationship between the various support systems and resilience in mathematics. Having a sig. value = 0.000, with $p < 0.05$, we reject the null hypothesis H_0: there is no relationship between support systems and resilience in

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mathematics in favour of H_1: there is a relationship between support systems and resilience in mathematics.

To determine the strength of the relationship, Cohen (1988) suggests a guideline: if the values of the correlation coefficient range from .10 to .29, there is a small relationship between variables. If the values of the correlation coefficient range from .30 to .49, there is a medium relationship between variables. If the values of the correlation coefficient are above .50, there is a large or strong relationship between variables (Cohen, 1988). Based on Cohen's correlation coefficient, there is a strong relationship between support systems and females' mathematical resilience (see Table 10).

4.6 Discussion of Findings

The study was conducted to investigate the life experiences of successful female mathematics professionals. This section provides a general discussion of the findings and it is done according to the objectives of the study.

1. **Challenging experiences of successful female mathematics professionals in their educational journey.**

Findings from the study revealed that most female students shy away from mathematics because of the inappropriate instructional methods employed by some teachers. To some extent, some teachers apply inappropriate instructional methods just because they might not have a professional mathematics educational background (as stated by one respondent). The data also discovered that, the negative attitude of some teachers towards females in the mathematics classroom instilled fear, hence their poor performance in mathematics. The finding is in agreement with the study of Salifu (2017) which revealed that the negative attitude of teachers and inappropriate instructional methods had caused females to run away from mathematics as a subject of study. Allotey (2012) also opined that the inappropriate method of teaching has made most female students to view

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mathematics as an “abstract black box” that contains nothing but complex, strictly held concepts and procedural imaginative formulae for memorization. The findings of the study make it clear that unhealthy school or teaching environment contribute greatly to females’ dislike of mathematics, hence their continues withdrawal from mathematics as a subject or programme of study. In addition, one respondent indicated that a teacher assumed that as females, they do not need to be good at mathematics. This is in consonance with O’Connor (2000) which stated that some teachers still hold on to the stereotypical cultural belief that females do not have the capability to cope with “difficult” subjects like mathematics hence, they discourage them from pursuing mathematics-related programmes.

Furthermore, within this current study it was discovered that socio-cultural belief and practices actually had impacts on females in their pursuit of mathematics-related programmes and careers. The study found that the stereotypic belief about the suitability of a programme or profession based on gender is still in existence. The females emphasized on the existence of the societal belief that, mathematics related disciplines are too difficult for females to study therefore, only males can study it, while arts and humanities were the suitable programmes for females to pursue. The study result is consistent with that of Adusah- Karikari, (2008) which discovered that most Ghanaian children are socialized from birth into male and female cultures by labelling some activities and programmes; such as Mathematics and Science as masculine and others such as Home Economics and Arts as feminine. Acheampong (2014) and Nosek et al. (2002) also confirmed that, the society holds the belief that femininity and the characteristics of mathematics are mutually exclusive. Acheampong (2014) further found that, most people believe women cannot pursue mathematics because, women by nature are nurturing and submissive hence they are supposed to read Art and Home science

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programmes. In addition, the study uncovered that in some Ghanaian societies, women were discriminated against not only in the study of mathematics-related disciplines but in general education as a whole. The burden of women performing household chores, coupled with the pressure to marry early before furthering their education was some of the experiences of female mathematics professionals. This is in agreement with what Ndirika and Agommouh (2017) emphasised in their work that, the lack of availability of time for home studies and having more domestic duties than boys in most African homes have negatively influenced the full participation of girls in science and mathematics programme to a high extend. Acheampong (2014) also confirmed that some parents have the perception that females' education ends at the kitchen and therefore need not to bother themselves with studies much less STEM disciplines. Cordova-Wentling and Camacho (2006) further opined that the societal beliefs and practices had devalued female students with respect to their mathematical ability and achievements.

Moreover, the study findings highlighted some sacrifices of females in order to perform their family responsibilities and also pursue their educational advancement. The female mathematics professionals unveiled their difficulties in managing multiple roles especially when they were married with children and advancing in their education. For instance, some of the females had to delay with pursuing higher degrees in order to focus on motherhood whiles others have to hold on with childbearing in order to focus on their education. Since the mother has to be nurturing, and the academician has to be productive and both duties are equally demanding, time consuming, and require a lot of sacrifices, one is always done at the expense of the other. Adu-Yeboah (2011) also came out with similar results indicating that, attaining higher degree especially in a STEM discipline is incompatible with motherhood and other domestic responsibilities, since it is time-consuming, demanding, and requires a lot of sacrifices. Recent studies (Boateng &

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Gaulee, 2019; Buse, et al., 2013) confirmed the findings of this study that although managing multiple roles apply to women in all professions, women in STEM disciplines have unique experiences due to the discrimination and masculine culture associated with male-dominated fields where women (forming the minority) have to work harder to be recognized in these fields.

Results from this study further revealed that the low economic status of some parents affected most females in their pursuit of degrees in mathematics disciplines. Similar to the findings by Ononye and Bong (2018), without monetary support many female students were not able to attain degrees in STEM education and were more likely to drop out. Moreover, in the Ghanaian society, most parents value the education of their sons more than their daughters. Some parents also have the perception that males are naturally good in mathematics relates programmes, so they prefer investing in their sons to pursue degrees in mathematics programmes than their daughters. These findings are in agreement with the findings of Acheampong (2014) which states that the society discourages most females from pursuing science and mathematics programmes because they view such programmes to be more expensive.

2. **Elements that facilitated the resilience of successful female mathematics professionals in the field of mathematics.**

For research question two, the study identified mathematical self-efficacy as an internal resilience factor which provide respondents with the tenacity to excel within the mathematics field. The study discovered mastery experience, vicarious experience and social messages or verbal persuasions as critical sources for the development and maintenance of females' mathematical self-efficacy beliefs. The findings of the study confirmed that of Zeldin and Pajares (2000) that women in mathematical, scientific, and technological disciplines used vicarious experiences, mastery experience and verbal

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persuasions from family members, teachers and peers to enhance their self-efficacy perceptions. The data further revealed that females had high self-efficacy belief regarding their competence, problem solving abilities and excellent performance on a given mathematics task. Thus, females who are aptly competent in mathematics often pursue mathematics-related careers because they have high self-efficacy perceptions about their competence. This finding is in agreement with the study of William (2019) which uncovered that females' mathematics efficacy belief provided a strong base for them to be resilient and persist in a male dominated field. Buse et al. (2013) also found that, women with sustained male-dominated careers demonstrated high sense of self-efficacy belief and a purposeful adaptation to the macho culture found in male-dominated professions than do women who leave the profession.

Furthermore, within the current study females emphasized on their self-confidence and determination to succeed as powerful motivators that affected the choices they made, the effort and persistence they put forth, and the resilience they show in overcoming the obstacles in their educational journey. The respondents explicitly stated that they were not going to quit or change their career path, because they felt destined to be in the mathematics field. That is not to say that they did not have obstacles or challenges that made them ponder the option to give up, however, respondents inherently emphasized that their confidence in their mathematics ability motivated them to persist through obstacles faced. The finding of the study is in agreement with that of Frazier-Kouassi et al. (1992) which stated that ambitious female students who demonstrated a high need for mathematical achievement were more likely to overcome barriers to success as they were willing to work hard and place greater emphasis on their mathematical achievement. Notwithstanding, it could be argued that these internal factors are essential to anyone, regardless of sex. Truly, most people benefit from having self-confidence and determined

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whether they are male or female. However, it is of greater priority for women in mathematics disciplines because most studies (Dimitriadi, 2013; Chachra & Kilgore, 2009) have identified females to have lower levels of confidence in their mathematical abilities, regardless of performance which are typically the same as the males.

Moreover, findings from the study discovered that the active participation of females in co-curricular activities (e.g., mathematics clubs and mathematics inter-schools' quizzes) and exposure to real-world learning opportunities through extra-curricular activities (mathematics field trips) increased females' confidence and resilience in mathematics. The study further found that early exposure and active participation of females in mathematics extra-curricular and co-curricular activities at a very young age was key in enhancing girls' competence in identifying themselves as future mathematics educators and scientists. Extra-curricular and co-curricular activities was noted to provide girls with experiential learning and investigative opportunities in academic areas that are not part of the regular school day, but play an integral role in shaping interest and confidence in mathematics disciplines (Bruyere et al., 2009). The results of this study is consistent with the findings of Edzie (2014) which showed that the involvement of female students in outreach programmes and out-of-school mathematics and science-related activities such as mathematics and science clubs, facilitated the development of female students' mathematics cognitive structure. Mukhwana et al. (2020) also found that the organization of mathematics quiz and competitions for girls with attractive motivational packages for those who excel was instrumental in promoting resilience and retention of females in mathematics disciplines.

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3. Support systems that influence the success of female mathematics professionals in the field of mathematics

The third research question of the present study found support systems (such as family Support, school support, peer support, role models and scholarships) as essential factors which help females to successfully manoeuvre their ways to gainfully attain a profession in the mathematics field. Family support came in diverse ways; leveraging resources, providing words of encouragement, and providing extra and private tuition to their female children. Most of the respondents identified and described their fathers as the most important person who guided and assisted them to navigate the complex pathway of the mathematics discipline and emerge successful. The finding of the study is similar to that of Hill et al. (2010), that parents who support their daughters to pursue mathematics-related disciplines provide the economic resources needed for them to be successful and also provide the motivation and affirmation needed to develop females' confidence in mathematics. Recent studies (Aunola et al., 2013; Hoffman et al., 2010) also confirmed the findings of this study that female students raised in homes that nurture self-confidence, competence, autonomy, and self-efficacy most pursue male-dominated disciplines. In addition, the study found that family support from spouses (the men) aided the success of females in their pursuit of higher degrees in mathematics. The respondents' descriptions of spousal support included: assisting with home management; academic support and encouragement from their spouse coupled with the financing of females' education. The finding of the study is consistent with what Murphy et al. (2007) found that, equitable treatment of men and women in domestic roles, allocation of resources, and provision of opportunities to advance, aids females to succeed and persist in any male-dominated field. Similar to the findings of this study, Barth et al. (2016) discovered that women with an egalitarian partner was successful in their STEM majors. Tiedeu et

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al. (2019) also found that it would be a huge national asset if partners would involve themselves in jointly carrying out family responsibilities.

Furthermore, a conducive school environment as well as support from teachers, especially those teaching mathematics at lower levels of education was identified in the study as an important factor that enabled females to successfully attain a mathematics career. Most females revealed that the support from teachers was mainly in the form of encouragement, funding of their education, offering remedial teaching, using reward systems as motivation and also letting females know that they had the potential to succeed in the mathematics field. The encouragement and enabling environment provided by teachers played a pivotal role in the lives of females from basic school experiences, throughout high school, and continued into their professional experiences as well. The findings of this study confirmed that of Mukhwana et al. (2020) which disclosed that the most important factor that enhanced the success of females in mathematics disciplines was the encouragement and confidence that teachers expressed in females' mathematical capabilities. According to UNESCO (2017), the application of appropriate instructional methods by teachers and the connection of abstract learning to a concrete situation through interaction with teaching and learning materials have proven effective in influencing the efficacy and success of females in STEM. This assertion was also evident in the findings of this study. In addition, the study discovered that school support from respondents' colleagues (particularly males) built a sense of belonging that increased the level of confidence in females' mathematical abilities and ultimately resulted in their retention in the mathematics discipline. The finding of the study is consistent with what Crosnoe et al. (2008) found that, female students who align themselves with peers who excel in mathematics, influence their mathematical achievement and motivates them to persist. Robnett (2013) also emphasized that peer

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support and connections enhanced girls' and women's confidence about their place in STEM by reducing the threat that is caused by social isolation.

Within this current study, it was discovered that females' accomplishments and successes resulted from mentors who were very positive and supportive during their educational journey. Significant among the mentoring relationships that emerged were STEM clinic programmes and some family members and teachers who served as role models. The finding of the study is in agreement with what Milgram (2011) found that, the secret to recruiting more girls to mathematics classrooms is no secret at all, that is, girls need to see female role models in the mathematics field that look like them, over and over and over again. Although most of the respondents recounted bitter experiences of not having enough female role models, they however appreciate the mentoring provided to them by their male mentors. Hill et al. (2010) discovered that exposing girls to successful female role models helped to counter negative stereotypes and increased their implicit mathematics identity needed to be successful in the mathematics field.

The findings from this study further disclosed that, scholarships offered by governmental and non-governmental agencies to females particularly in mathematics programmes were vital in facilitating a successful completion of females' mathematics studies. The financial support was mostly in form of payment of school fees for respondents at one stage of their education to ensure their smooth transition to the next level. The finding is consistent with the result of Ononye and Bong (2018) that indicated that scholarships enhanced the achievement rate and promoted access and persistence of female students in STEM programmes. Thus, without monetary support many female students may not be able to attain degrees in STEM education and were more likely to drop out. In addition, Mukhwana et al. (2020) found that providing funds for women graduate

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students is one strategy for increasing the presence, retention, and advancement of women in the male dominated profession.

4. **The relationship between support systems and females' mathematical resilience**

For the research question four, the Pearson product-moment correlation was carried out to find the relationship between various support systems (such as school support and family support) and females' mathematical resilience. The results of the Pearson product-moment correlations indicated a statistically significant positive correlation between school support system and females' mathematical resilience. The findings of this study confirmed what earlier studies (Arastaman, & Balci, 2013; Chirkina et al., 2020; Liew et al., 2018; Unsal et al., 2018) found, that there is a positive significant correlation between school related factors and students' resilience in mathematics. The strong correlation between the school support variable and students' mathematical resilience revealed that the school made mathematics valuable and interesting to female students. Besides, creating a safe space in the classroom where students cooperate and support one another was a useful strategy for promoting students' resilience in mathematics (Alivernini et al., 2016). Examples of the school support variables include supportive teachers, conducive school environment, appropriate methods of teaching, availability of teaching and learning materials and supportive peers.

Additionally, there was a strong positive correlation between family support system and females' mathematical resilience. The results of this study also concur with the findings of these studies (e.g, Arastaman, & Balci, 2013; Tok & Ünal 2020). The family variable showed that the support from home, made female students to persevere despite the difficulties and challenges they encountered in their study of mathematics. According to Corak (2013), parents' investment on children's education is not only monetary but also

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nonmonetary (in terms of motivation and aspiration). Thus, positive feedback from parents gives female students the ability of resilience and perseverance in the mathematics discipline.

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CHAPTER 5

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Overview

This chapter provided a summary of the study and the key findings. It also highlighted the conclusion of the study and also outlined some recommendations and areas for future research.

5.1 Summary of Study

The purpose of the study was to investigate the life experiences of successful female mathematics professionals. The researcher was also interested in finding out the elements that facilitated the resilience of these successful women and determining the support systems that influence their success, thereby contributing to the alternative knowledge construction about women in mathematics. The study employed the resilience theory to identify the factors that have contributed to the success of females in mathematics fields and better understand how they overcame socio-cultural practices as well as some gender-biased educational practices.

The study was guided by the following research questions:

1. what are the life experiences of successful female mathematics professionals in their educational journey?
2. what facilitated the resiliency of successful female mathematics professionals in the field of mathematics?
3. what support systems influence the success of female mathematics professionals?
4. what is the relationship between support systems and females' mathematical resilience

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The study employed the sequential explanatory mixed-methods research approach (Creswell, 2012). The study consists of 70 female mathematics professionals which were selected through the purposive sampling technique; 10 female lecturers and 60 female MPhil students (who are mathematics professionals) in Ghanaian tertiary institutions in Greater Accra and the Central region. In addition to the purposive sampling technique, the researcher also employed the Snowball sampling strategy. Questionnaires and interviews were the main instruments used for data collection. Data collected from the questionnaires were analysed using descriptive statistics (i.e., frequency distribution, percentages and charts) and inferential statistics (i.e., Pearson's product-moment correlation). In addition, thematic analysis was used to analyse the qualitative data.

For research question one, the study discovered an unhealthy school environment, managing multiple roles, sociocultural practices and beliefs, as well as financial challenges as the challenging experiences of female mathematics professionals in their educational and career journeys. The study found that most female students shy away from mathematics because of some teachers' inappropriate teaching strategies and their negative attitudes toward female students in the mathematics classroom. It was also discovered that females' pursuit of the mathematics discipline was hampered by the stereotypical belief about the suitability of a programme or career based on gender. In some Ghanaian societies, the burden of performing household chores and the pressure to get married early affected women not only in the study of the mathematics-related programme but also in general education. Additionally, most females found it difficult combining family life, academic work and the mathematics profession. The research found that studying as a mathematical educator or scientist was very demanding, time-consuming, and, from time to time, required putting in extra hours beyond what is

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normal. Results from the study further revealed that the low economic status of some parents affected most females in their pursuit of degrees in mathematics disciplines.

Research question two revealed internal factors (such as mathematical self-efficacy, high aptitude, determination and confidence in mathematics) in addition to external factors (such as active participation in co-curricular and extra-curricular activities) as some of the common factors that had contributed to females' resilience and sustainability in the mathematics discipline. Females made reference to their mastery experience, vicarious experience and verbal persuasions as major pillars of self-efficacy which increased their resilience and persistence in the mathematics field. The study further found that early exposure and active participation of females in mathematics extra-curricular and co-curricular activities at a very young age was key in enhancing girls' competence in identifying themselves as future mathematics educators and scientists.

The third research question identified support systems (such as family support, school support, peer support, role models and scholarships) as essential factors which helped females to successfully manoeuvre their ways to gainfully attain a profession in the mathematics field. The females identified and described their fathers and spouses as the most important members of the family who guided and assisted them to navigate the complex pathway of the mathematics discipline and attain higher degrees. Females' descriptions of spousal support included: assisting with home management; academic support and encouragement coupled with the financing of their education. The outpouring of unconditional support and guidance in addition to the application of appropriate instructional methods by teachers and the connection of abstract learning to a concrete situation through interaction with teaching and learning materials was proven effective in influencing the efficacy and success of females in the mathematics discipline.

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Also, females' colleagues' (particularly the males) support through activities like peer tutoring and study groups was mostly in the form of explaining concepts that were conceptually difficult to females for better understanding. Significant among the mentoring relationships that emerged in the study were organised programmes like STEM clinics and some family members and teachers who served as role models. Although most of the females recounted bitter experiences of not having female role models, they, however, appreciate the mentoring provided to them by their male mentors. The study further disclosed that scholarships offered by governmental and non-governmental agencies to females, particularly in mathematics programmes were vital in ensuring females' smooth transition from one stage of their education to the next level.

For research question four, the results of the Pearson product-moment correlations indicated a statistically significant positive correlation $r = 0.622$ between family support system and females' mathematical resilience. Additionally, there was a strong positive correlation 0.653 between the school support system and females' mathematical resilience.

5.2 Conclusion

The study draws the following conclusions.

- An unhealthy school environment, managing multiple roles, sociocultural practices and beliefs, as well as financial challenges constitute the challenging experiences of females in their mathematics educational journey.
- Internal resilience (such as mathematical self-efficacy, determination andself-confidence) as well as external resilience (eg., co-curricular and extracurricular activities) were identified as essentials for females' persistence in mathematics disciplines.

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- Family support, mentoring, school support and scholarships had a large positive effect on the advancement and retention of females in the mathematics disciplines.

5.3 Recommendations

Based on the conclusions, it is recommended that:

1. The school should create a conducive and healthy classroom environment for female students by adopting appropriate methods of teaching which connect mathematics to real life situations and the right attitude towards females.
2. Policymaker and implementers should take a keen interest in creating the needed career opportunity awareness for female students who participate in mathematics programmes.
3. STEM clinics should be organised in all districts to foster the mentoring of female students in mathematics and science programmes.
4. The government and non-governmental organizations should provide more scholarships for female students' participating in mathematics related programmes.
5. Parents should put in measures that will help develop the mathematical resilience of females by making the girls aware that abilities in mathematics are not fixed and can be improved upon through consistent effort and hard work.

5.4 Suggestions for Areas of Further Research

The following are recommended for further research:

- studying females of a large sample size, that is, female mathematics professionals across all tertiary institutions in Ghana may yield more concrete findings. This would also allow greater validity of the study's findings.

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- it is suggested that this study should be replicated in other male dominated fields (such as Physics, Engineering and Technology).
- a study investigating the factors that influence girls in senior high schools to choose elective mathematics could go a long way to provide more insights into “how to catch them young”. since a lack of participation at the senior high school will lead to underrepresentation at the tertiary level.

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APPENDIX A

QUESTIONNAIRE FOR FEMALE MATHEMATICS PROFESSIONALS

UNIVERSITY OF EDUCATION, WINNEBA

FACULTY OF SCIENCE EDUCATION

DEPARTMENT OF MATHEMATICS EDUCATION.

The information that you will provide in this questionnaire is anonymous and will only be accessed by one researcher. You will not be identified anywhere in this research study and you are not required to provide your name in the questionnaire. All information provided here shall be kept confidential and shall be used for research purposes only. Thank You.

A. DEMOGRAPHIC INFORMATION

Please tick (✓) in the appropriate space provided below where applicable

1. Your profession:

[ ] Female Mathematics Professional

2. Age range:

21-30 [ ] 31-40 [ ] 41-50 [ ] Above 50 years [ ]

3. Number of Years in service

1 - 5 years [ ] 6 - 10 years [ ] 11 – 15 years [ ] Above 16 years [ ]

4. Highest level of education?

Bachelor's Degree (but pursuing master's degree) [ ] Master's Degree [ ]

Doctoral Degree (PhD) [ ]

5. Father's highest level of education

BECE/O Level [ ] SSSCE/A Level [ ] HND/Diploma [ ]

First Degree [ ] Masters [ ] PHD [ ]

No formal education [ ]

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6. Mother's highest level of education

BECE/O Level [ ] SSCE/A Level [ ] HND/Diploma [ ]

First Degree [ ] Masters [ ] PHD [ ]

No formal education [ ]

For the remaining of the questions, please choose the answer that best fits your opinion

using the following scale: Strongly Agree (SA); Agree(A); Neutral (N); Disagree(D); Strongly Disagree (SD)

SECTION B: Life Experiences of Respondents Whilst Pursuing Mathematics

S/N	ITEMS	SA	A	N	D	SD
1	As a young lady pursuing mathematics, there were no female mathematics role models to emulate					
2	Whilst pursuing my education, most of my teachers applied inappropriate instructional methods during mathematics lessons					
3	Whilst pursuing my education, my school lacked adequate teaching and learning materials needed for the study of mathematics					
4	As a young lady pursuing mathematics, most of my teachers had negative attitude towards girls during mathematics lessons.					
5	As a young lady pursuing mathematics, I was not given enough counselling on the various careers associated with mathematics.					
6	As a young lady growing up in the Ghanaian society, most people in my immediate environment held the perception that Mathematics is a male domain and not for females (like me).					
7	As a young lady pursuing mathematics, my father was not supportive of my desire in attaining a mathematics career.					

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8	My mother was not supportive of my desire in attaining a mathematics career					
9	As a young girl pursuing mathematics, I frequently faced financial instability which affected my interest in mathematics					
10	Whilst pursuing my education, I mostly face difficulties because of the abstract nature of mathematics.					
11	As a young lady pursuing mathematics, my peers attribute my high performance in mathematics as a result to flirting with the tutors					
12	As a young lady growing up in the Ghanaian society, most people held the perception that the woman's place is the kitchen and not to study mathematics					

SECTION C: Factors That Facilitated Respondent's Resilience

S/N	ITEMS	SA	A	N	D	SD
13	My frequent high-Performance during mathematics lessons facilitated my resilience in pursuing a mathematics career					
14	My strong confidence level in performing a mathematics task facilitated my resilience to pursue a mathematics profession					
15	As a young lady growing up, my great passion in attaining a mathematics career facilitated my resilience to pursue mathematics					
16	My resilience in pursuing a mathematics career was facilitated by my high level of self-efficacy in mathematical achievements					
17	I will attribute my resilience in pursuing a mathematics career to perseverance and persistence					

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18	My mathematical curiosity and wide interest in mathematics as a subject facilitated my resilience to pursue mathematics to the highest level					
19	The motivation from my parents that mathematics is applied in everyday life facilitated my resilience to pursue a mathematics career					
20	My participation in mathematics extra-curricular activities facilitated my resilience to attain a mathematics profession					
21	My female mathematics teacher served as a role model for me to pursue a mathematics career.					
22	As a young lady, I had early aspirations of becoming a mathematics professional					
23	My teacher made the abstract nature of mathematics very practical and real.					
24	My parent's mathematics related profession steered me towards attaining a mathematics career					
25	As a young lady pursuing mathematics the frequent praises from my immediate society facilitated my resilience to attain a mathematics profession					

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SECTION D: Support Systems That Ascribe to Respondents' Success in Mathematics.

S/N	ITEMS	SA	A	N	D	SD
	Family Support					
26	My parents provided me with relevant materials and resources needed for learning and attaining a mathematics profession					
27	My parents provided me with extra tuition at home for my great achievement in mathematics					
28	As a young lady, my parents took me to mathematics museums that steered my interest in mathematics					
29	My mother had always supported my desire to pursue and attain a mathematics profession					
30	My father had always supported my passion to pursue and attain a mathematics profession					
31	I experience countless and diverse support from my siblings whiles pursuing my education					
32	As a young lady, my parents provided me with tinker toys which created my desire to pursue mathematics					
	School Support					
33	My school created a conducive mathematics learning environment for me.					
34	My school provided me with relevant materials and resources needed for learning and attaining a mathematics profession					
35	My school counsellors often coach me in various careers in mathematics.					
36	My peers supported me through peer learning whilst pursuing my mathematic education					
37	My school made provision of scholarship for females pursuing mathematics					

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38	My teacher created opportunities for learning and practice of mathematics inside and outside the classroom					
39	It was my teacher who encourage and fueled my confidence to pursue mathematics profession					
40	The frequent career guidance sessions organize in my school steered my passion for a mathematics career					
41	My school created the avenue for me to have mentoring and interactions with mathematics female role models					

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APPENDIX B

SEMI-STRUCTURED INTERVIEW PROTOCOL

Questions about your educational experience as a female mathematics professional

1. When did you first become interested in mathematics? or What sparked your interest in mathematics?
2. How did you arrive at the decision to be a mathematics professional?
3. How would you describe your educational experience as a female student in the mathematics classroom? (From the basic level to doctorate degree)
    a. Recall a period in your mathematics educational journey when you felt there were challenges (from the family, school, society or friends)
4. What strategies or actions did you take to allow you to overcome these challenges?
5. I want to know if you have ever heard or thought of the term "resiliency". How would you explain "resiliency" with respect to your mathematics educational journey?
    a. Was there a time when you felt empowered or inspired during your educational journey?
6. Tell me about the support systems that influence your success in your mathematics educational journey. Possible follow-up questions:
    a. Support from family (parents, siblings or extended family)?
    b. Support from the school (precisely teachers and peers)
    c. Any scholarship awarded?
    d. Impact of a role model?
    e. Other.

7. Is there anything else you would like to add or share about this topic that you feel is important for me to know?

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APPENDIX C

RELIABILITY TEST STATISTICS

Reliability Test Statistics

Cronbach's Alpha	N of Items
.834	41

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APPENDIX D

TESTING OF LINEARITY FOR PEASON'S PRODUCT-MOMENT CORRELATION ANALYSIS

Figure 4

Scatter plot of School support and mathematical resilience

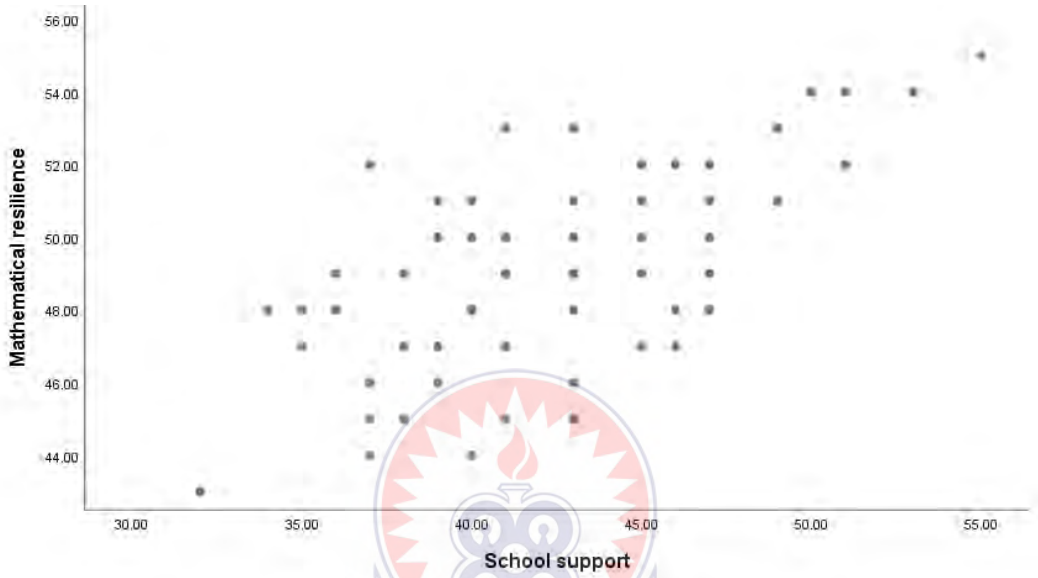
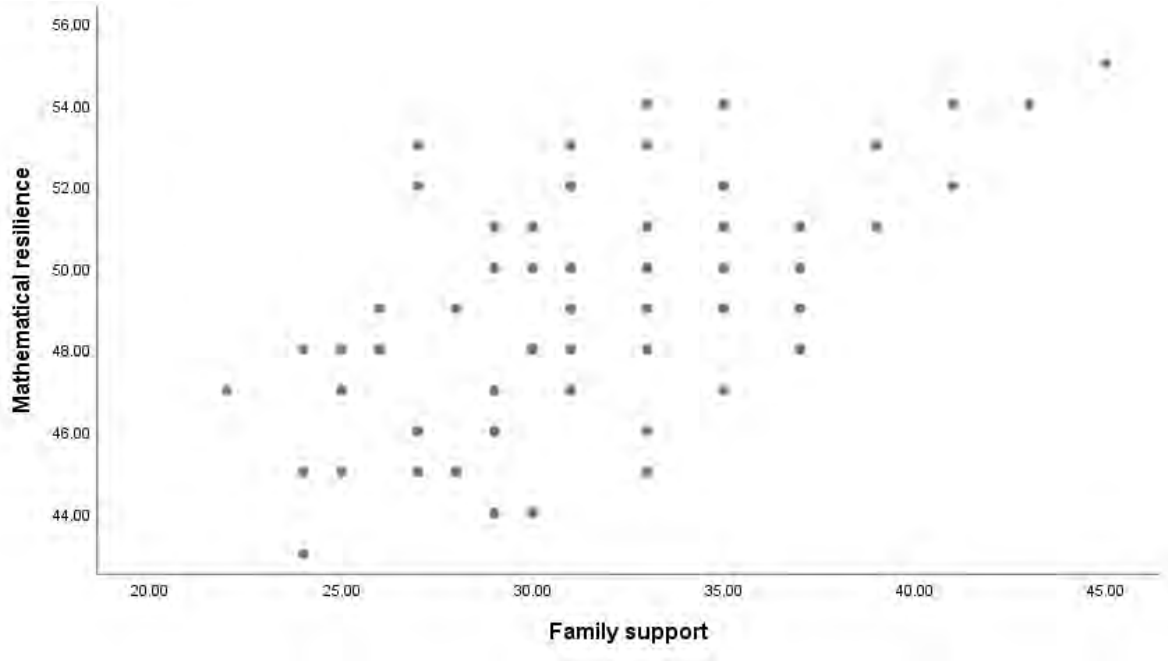


Figure 5

Scatter plot of family support and mathematical resilience



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APPENDIX E

TESTING OF NORMALITY FOR PEASON'S PRODUCT-MOMENT CORRELATION ANALYSIS

Figure 6

Histogram of school support

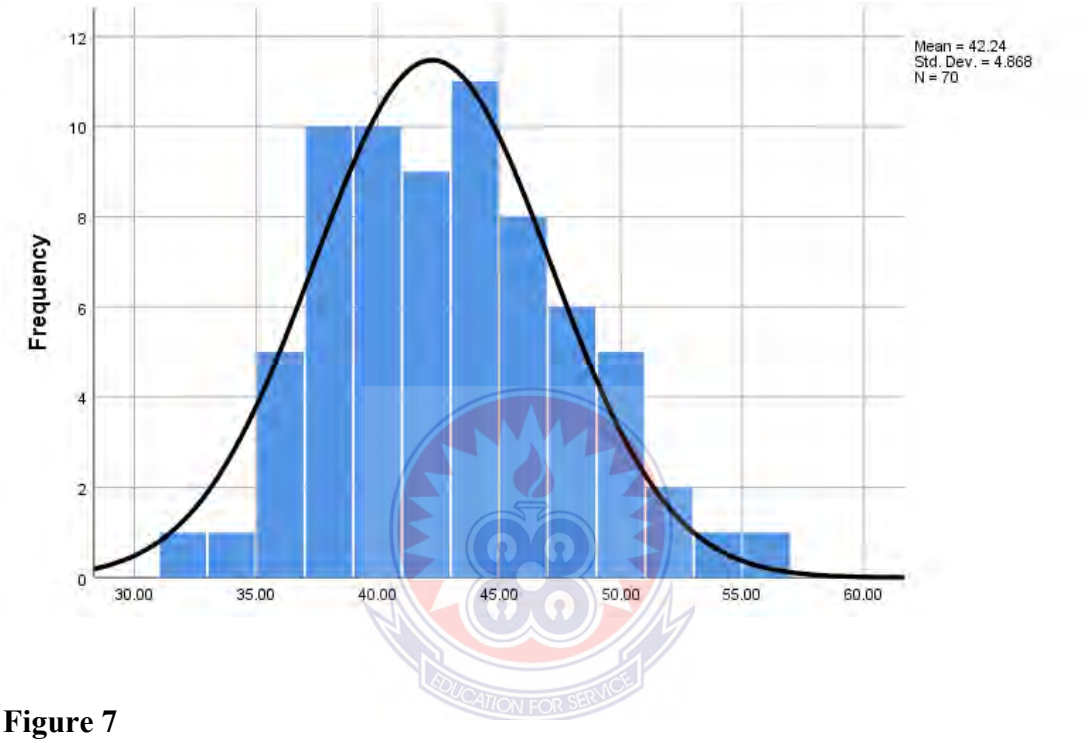

Figure 7

Histogram of family support

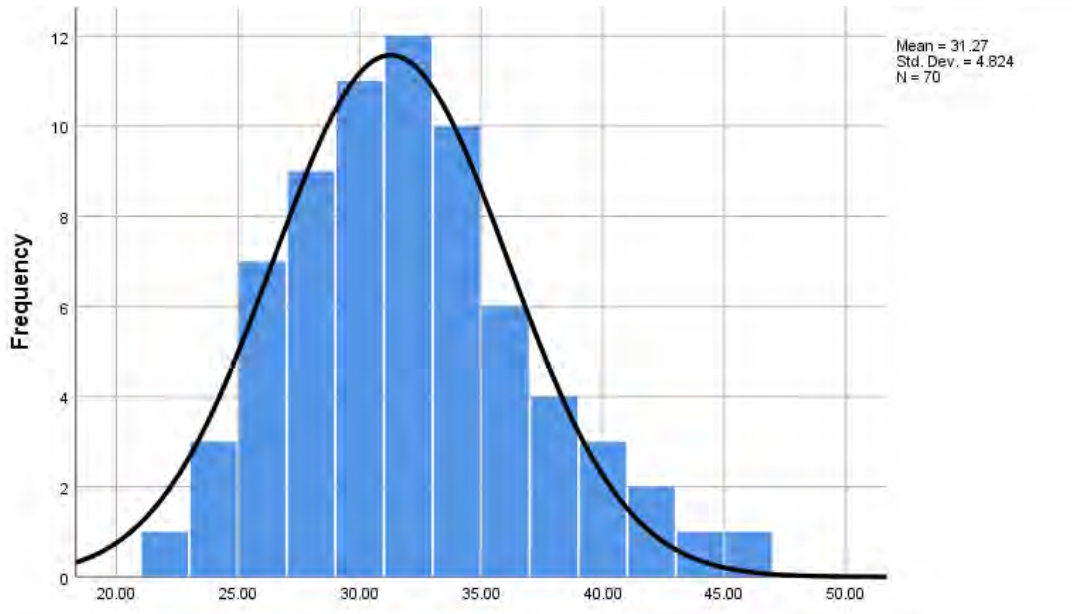

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Figure 8

Histogram of mathematical resilience