A Case Study of Teachers' Perspectives on Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana

by

Michael Osei-Owusu

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF EDUCATION

Department of Curriculum, Teaching and Learning

University of Manitoba

Winnipeg

Abstract

This study explores teachers' perspectives on misconceptions and myths about mathematics learning among Ghanaian middle school students and the possible factors contributing to these misconceptions and myths. Such misconceptions and myths are well-documented globally but less understood in the Ghanaian context. Grounded in theories from Piaget and Vygotsky, the study employed a qualitative case study design, guided by an Integrated Teacher Student Environment model. Data were collected through teacher interviews and classroom observations and analyzed using deductive thematic analysis. The findings reveal that teachers believe students have misconceptions about mathematics dimensions such as adding or subtracting unlike terms, operations involving negative numbers, and operations involving different measurement units. Teachers believe that students also exhibit several myths about mathematics learning, including its perceived difficulty, gendered suitability, the myth of inherited mathematical competence, and the belief that mathematics requires memorization. These teachers also believe that traditional instructional practices, teacher discomfort with mathematics, students' lack of confidence in their mathematical abilities, and socio-cultural influences may be contributing factors. These findings highlight the need for instructional reforms that actively address the myths and misconceptions students hold about mathematics by promoting conceptual understanding, challenging stereotypes, and creating a more inclusive and confidence-building learning environment.

Acknowledgements

I am deeply grateful to the University of Manitoba for the academic and financial support that made this study possible. I would like to express my profound gratitude to my program advisor, Dr. Christopher Charles, for his continued support and guidance during my study. Also, my sincere gratitude to my advisory committee members: Dr. Martha Koch and Dr. Latika Raisinghani for their support and insightful feedback throughout this journey. Your contributions have had a lasting impact on my academic growth.

A special gratitude to my spouse, Helen Akweley Mensah, for your love, patience, and constant encouragement. Your love and encouragement have been a source of strength and inspiration to my academic journey.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

While teaching in Ghanaian basic schools, I observed that students often struggle with mathematical notations, particularly the dual nature of expressions representing processes and objects. For example, (5y + 4) can be seen as a process (adding five times (y) and four) or as an object (the expression itself). This duality can be confusing, as students may not always discern when to treat an expression as an object or a process. Dreyfus et al. (1990) noted that students often simplify expressions like (5y + 4) to (9y), failing to recognize when the expression should be considered an object as well as failing to recognize that 5y and 4 are not like terms.

Another common misconception I observed involves the equal sign. Students frequently misinterpret it as a result indicator rather than understanding its relational properties, which signify equality and transitivity (Kieran et al., 1990). This misunderstanding contributes to students viewing mathematics as a linear process focused on finding the "correct answer." For instance, they may assume all expressions are solved from left to right, struggling with problems like (_ + 2 = 8) where the answer is given, and the missing number must be found (Watson & Mason, 2005).

I observed a significant misconception in my Grade 7 mathematics classroom during a lesson on calculating the area of rectangles. I provided each student with a rectangular shape that appeared visually similar to the others but had slightly different dimensions—altered subtly by 0.5 cm or 1 cm. Each student measured their rectangle's length and width, calculated the area, and then compared their results with peers. During the class discussion, many students were surprised that their calculated areas differed, despite the shapes exhibiting perceived visual similarity. Some debated whose answer was correct, assuming there should be only one right answer. This revealed a key misconception: the belief that when geometric figures appear

visually similar, they must have identical dimensions and, therefore, yield the same mathematical result. It also reflected the broader misconception that mathematics problems always have a single, universal solution. In reality, each student had a unique rectangle with its own measurements, so each calculation was correct based on their individual dimensions. It is important to note that if all students had been given rectangles with identical dimensions, their calculated areas would indeed have been the same. However, since the rectangles provided differed slightly in dimesions, each student's answer was valid based on the unique dimensions of their specific figure. The confusion did not stem from the existence of multiple correct answers to a single problem, but from a misunderstanding of how subtle differences in dimensions affect mathematical outcomes, and a reliance on perceived visual similarity rather than precise measurement. Such preconceived notion led to misunderstandings, despite the students' accurate calculations. These observations provided the impetus for my study, *A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana*.

In this chapter, I begin by defining key terms that lay the groundwork for the study. I then present an overview of education in the Ghanaian context, highlighting the key features and dynamics that shape the educational experiences of students. Following this, I outline the statement of the problem, the objectives, and research questions of the study. Finally, I discuss the significance of the study, my background, and the structure of the thesis.

Definition of Key Terms

To help readers understand important concepts in this study, I provide the following definitions:

- *Basic School* – In Ghana, basic school encompasses the foundational and compulsory education from Kindergarten through Grade 9. Recent educational reforms, as outlined in

the National Pre-tertiary Education Curriculum Framework (2018), have expanded this definition to include Senior High School (SHS 1-3) or Grades 10-12. In this study, the terms Grade 7, 8, and 9 and Basic 7, 8, and 9 are used interchangeably to refer to the same levels within the Ghanaian basic education system.

- *Myth* – In this study, a myth is defined as an unjustified or false belief about mathematics and mathematics teaching and learning (Merriam-Webster, n.d.).
- *Misconception* - Misconception is a misunderstanding of mathematics concepts (Jamaludin & Maat, 2020).

Education in the Ghanaian Context

The basic school curriculum (2019) in Ghana places an increasing emphasis on mathematics education to act as the foundation that ensures students are academically and professionally successful. Mathematics is the foundation that helps students develop the analytical and problem-solving skills required to address complex challenges and actively participate in national development (National Council of Teachers of Mathematics, 2014). Recognizing this, Ghana's educational framework prioritizes teaching practices that foster active learning and promote a deep understanding of mathematical concepts (Ministry of Education, 2020).

This viewpoint reflects the pivotal role of mathematics education in shaping students into critical thinkers, innovators, and problem-solvers who can actively contribute to the nation's growth and development. A good mathematics foundation supports individuals to be successful academically and provides a workforce with well-grounded skills to promote socioeconomic development and innovation in Ghana (National Pre-tertiary Education Curriculum Framework, 2018). By developing an analytical way of thinking that includes creativity, students gain

preparation for careers in sectors crucial to the development of Ghana. This will be achieved only if mathematics education in Ghana tackles some of the challenges in the educational system (National Pre-tertiary Education Curriculum Framework, 2018).

The educational sector faces significant challenges in numeracy. This is evidenced by the 2016 National Education Assessment, which reported that only 22% of primary school class 4 students (approximately 8-12 years of age) achieved proficiency in numeracy (National Pre-tertiary Education Curriculum Framework, 2018). The low numeracy proficiency among primary school class 4 students in Ghana may be attributed to several factors. One critical factor may be the reliance on traditional, rote-based teaching methods in mathematics classrooms. These methods prioritize memorization over fostering a deep understanding of mathematical concepts, leaving many students unable to apply these concepts in practical scenarios. Without opportunities for hands-on, interactive learning, students struggle to build the critical thinking and problem-solving skills necessary for numeracy proficiency (National Pre-tertiary Education Curriculum Framework, 2018).

Another factor may be the lack of adequate learning resources in many schools. Many classrooms are under-resourced, with insufficient textbooks, manipulatives, and teaching aids to support effective mathematics learning. Without these materials, students opportunities to engage with mathematical concepts in meaningful and interactive ways are further limited. Through my teaching experience, I have observed that students do not engage in hands-on learning activities that may improve understanding of mathematics concepts. This issue may be a barrier to achieving better numeracy skills among basic school students in Ghana. With its emphasis on mathematics education, Ghana hopes to develop future generations that can apply analytical skills, creativity, and innovation in solving real-life problems (National Pre-tertiary Education

Curriculum Framework, 2018). This commitment to fostering mathematical competence highlights its critical role in preparing students for individual success and collective progress as contributors to the nation's socioeconomic transformation (National Pre-tertiary Education Curriculum Framework, 2018).

The Structure of Pre-tertiary Education in Ghana

Ghana runs a centralized curriculum at the pre-tertiary level across its 16 regions. The curriculum is designed by the National Council for Curriculum and Assessment (NaCCA), which is an organization under the Ministry of Education. Ghana's pre-tertiary education system has undergone recent reforms that have redefined Basic Education to include Senior High education.

The structure of Ghana's pre-tertiary education system is organized into five key phases, each with specific objectives and focus areas designed to guide students through their educational journey. At each phase, mathematics is a core subject, reinforcing its importance in providing students with essential skills in numeracy, algebra and geometry. These skills are progressively developed to prepare students for their future academic and professional endeavours. These phases are aligned with the National Pre-tertiary Education Curriculum Framework (2018), which emphasizes foundational learning, intellectual development, and career preparation. Table 1 shows a concise overview of these phases, highlighting the grade levels, age ranges, and core objectives associated with each stage.

Table 1

The Structure of Pre-tertiary Education in Ghana

Key Phase	Level	Grade	Age Range (In years)	Focus and Objectives

1	Kindergarten (KG)	KG 1-2	4 - 5	Introduces formal schooling; fosters a love for learning and builds a foundation for future education
2	Lower Primary	1-3	5 - 8	Reinforces fundamental skills from KG; builds a strong base for further learning.
3	Upper Primary	4-6	8 - 12	Encourages curiosity, creativity, and invention; provides building blocks for higher education
4	Junior high school (JHS)	7-9	12 - 15	Introduces lower secondary education; helps students explore interests and aptitudes; prepares for careers, entrepreneurship, and vocational training; prepares students for the Basic Education Certificate examination (BECE).
5	Senior high school (SHS)	10-12	15 - 18	Specializes in academic and vocational programs; prepares students for the West African Senior School Certificate Examination (WASSCE) and further education or training through apprenticeship programs.

Successful graduates from the SHS gain admission to various tertiary institutions, including universities, polytechnics, and specialized institutions like nursing training colleges and colleges of education. Mathematics plays a pivotal role in this achievement, as it forms part of the admission criteria for most tertiary programs (National Pre-tertiary Education Curriculum Framework, 2018) and equips students with essential skills for their academic growth and career advancement. This holistic and structured approach to pre-tertiary education is intended to ensure a comprehensive and progressive development of students, preparing them for both academic pursuits and the dynamic challenges of the modern workforce (National Pre-tertiary Education Curriculum Framework, 2018). The phased structure is purported to accommodate diverse learning needs and to reflect a strategic and adaptable framework which emphasize standards and competencies rather than subject content (National Pre-tertiary Education Curriculum Framework, 2018).

Ghana's Education Strategic Plan 2018-2030

Ghana's Education Strategic Plan outlines three key priority areas (National Pre-tertiary Education Curriculum Framework, 2018). Firstly, it emphasizes improved equitable access to inclusive quality education at all levels. This priority seeks to bridge disparities between rural and urban schools and ensure that students from all socioeconomic backgrounds have access to education that meets global standards. Equity in education is critical in the Ghanaian context, where significant gaps in resources, infrastructure, and teacher quality exist (National Pre-tertiary Education Curriculum Framework, 2018). Achieving this goal is essential to narrowing regional inequalities and empowering marginalized communities.

Secondly, the plan focuses on enhancing the quality of teaching and learning, particularly in science, technology, engineering, and mathematics (STEM). Mathematics forms a foundational component of STEM education. Strengthening teaching and learning practices in mathematics and other STEM subjects is seen as essential for equipping students with the problem-solving, critical thinking, and analytical skills required for Ghana's socioeconomic progress. Improved teaching and learning in mathematics can help students gain a deep understanding of mathematics concepts and build confidence in their problem-solving abilities (National Pre-tertiary Education Curriculum Framework, 2018). Failure in this area would leave students unprepared for the demands of higher education and STEM careers, limiting their opportunities to contribute meaningfully to Ghana's development.

Lastly, the plan highlights sustainable and efficient management, financing, and accountability in education (National Pre-tertiary Education Curriculum Framework, 2018). This area highlights the importance of prudent resource allocation, effective governance, and robust monitoring systems to improve educational outcomes. Without addressing this priority, systemic inefficiencies such as inadequate funding, poor accountability, and weak policy implementation will persist.

These three priorities are interconnected, and their success is crucial for transforming Ghana's education system to support national development. There is general consensus among education policy makers in Ghana that improved mathematics education is crucial to achieving the strategic plan's larger objectives, which include workforce development, student achievement, and the country's economic advancement (National Pre-tertiary Education Curriculum Framework, 2018).

Transitioning from an Objective-Based to a Standards-Based Curriculum

The Ghanaian curriculum used previously (2007) faced significant challenges that necessitated reform. Being objective-based, it placed a strong emphasis on theoretical knowledge, which limited students' ability to apply mathematical concepts to real-world contexts (National Pre-tertiary Education Curriculum Framework, 2018). Teachers implemented the curriculum by prioritizing the acquisition of factual knowledge over the development of conceptual understanding and practical competencies (National Pre-tertiary Education Curriculum Framework, 2018). Consequently, mathematics education often failed to engage students meaningfully, leaving them inadequately prepared to use mathematical concepts and skills in solving everyday problems (National Pre-tertiary Education Curriculum Framework, 2018).

Moreover, the examination-driven assessment system reinforced this focus on rote learning, placing greater value on the recall of memorized information rather than the application of critical thinking and problem-solving skills (National Pre-tertiary Education Curriculum Framework, 2018). This approach constrained the teaching and learning of mathematics by emphasizing what students could reproduce in examinations rather than their ability to utilize mathematical knowledge in diverse and practical contexts (National Pre-tertiary Education Curriculum Framework, 2018).

A review of the objective-based curriculum was necessary due to a national priority to shift from examination-oriented learning to character-building and value-nurturing education (National Pre-tertiary Education Curriculum Framework, 2018). This led to the implementation of a standards-based curriculum, aligning with global educational trends that emphasize competencies and measurable standards for fostering sustainable learning outcomes (National

Pre-tertiary Education Curriculum Framework, 2018). By focusing on critical thinking, problem-solving, and the practical application of knowledge, the standards-based curriculum aims to equip students with skills relevant to real-world challenges, ensuring that education contributes meaningfully to both individual growth and national development (National Pre-tertiary Education Curriculum Framework, 2018). While the curriculum reform is a critical step forward, persistent issues in mathematics education exist and it is likely that students still grapple with misconceptions and myths about mathematics learning.

Statement of the Problem

Mathematics is a critical subject for basic school students in Ghana, particularly those preparing for their Basic Education Certificate Examination (BECE), a final examination taken by Grade 9 students before entering senior high school (SHS). Success in mathematics is a key requirement for gaining admission into senior high school programs, and failure in this subject can have significant implications for students' educational pathways. However, research in other contexts suggests that students often encounter misconceptions and myths about mathematics that hinder their understanding, progress, and attitudes toward the subject (Hiebert & Grouws, 2007). These misconceptions, if not addressed in the early stages of learning, can negatively affect students' ability to grasp mathematical concepts as they advance to higher grades or classes (Kshetree et al., 2021). The presence of myths about mathematics teaching and learning can affect students' confidence and reduce their motivation to engage with the subject (Chestnut et al., 2018). With time, these myths may distort students' perceptions of mathematics and hinder the development of critical thinking and problem-solving skills (Chestnut et al., 2018).

Recognizing this problem, this study investigates teachers' views about the misconceptions and myths that basic school students hold about mathematics learning. Several studies (Acharya,

2017; Stothard, 2021; Jankvist & Niss, 2018) have identified a range of misconceptions exhibited by elementary school students in various countries. These studies concluded that misconceptions could impact students' performance in mathematics. However, I was unable to locate many studies investigating the specific nature of misconceptions and myths and the factors that may contribute to them in the Ghanaian basic school context. Fletcher et al. (2014) conducted a study with 40 mathematics teachers in the Akatsi District, focusing on schools with poor performance in the 2010 BECE. The study found that while most teachers could identify common misconceptions among students, they were unable to explain the factors contributing to these issues. Beyond this study, there is a notable gap in the literature regarding the specific nature of misconceptions and myths, as well as the contributing factors, within the Ghanaian context. This study aims to address that gap.

This study addresses this gap for a number of reasons. First, misconceptions and myths in mathematics may contribute to ongoing learning challenges, as foundational misunderstandings hinder the ability to grasp more advanced concepts (Stothard, 2021). Second, without a clearer insight into the nature of misconceptions and myths and the underlying factors, it becomes difficult to develop targeted interventions to address them. Addressing this gap will provide valuable information for improving mathematics teaching and learning, with the potential to foster more positive attitudes toward mathematics and enhance students' academic success. In Ghana, where mathematics is a core subject across all pre-tertiary levels, it is possible that such misconceptions and myths could result in reduced interest in STEM-related disciplines. This issue is particularly concerning given the government's prioritization of STEM education as a critical component for national development.

This study offers insights into teachers' perspectives on the misconceptions and myths that basic school students hold about mathematics, as well as the factors that teachers believe contribute to the development of these misconceptions and myths.

Research Questions

The study seeks to gain insights into the following questions:

1. What are teachers' perspectives on the misconceptions and myths that basic school students in Ghana exhibit in their mathematics learning?
2. What factors do teachers perceive as contributing to the development and persistence of these misconceptions and myths among basic school students in Ghana?

Background of the Researcher

With over a decade of experience as an elementary school mathematics teacher in Ghana, I have lived experiences and insights into the challenges that mathematics teachers face, particularly those working in rural communities. I began my teaching career in 2012 at Akoteykrom No.1 D/A Basic School, where I taught mathematics from Grades 7 to 9 after completing my teacher training at Accra College of Education. Despite my formal training, my initial years of teaching were marked by challenges. As a new teacher, I grappled with finding effective methods to engage students who showed minimal interest in mathematics. Many of these students held negative perceptions toward the subject, often skipping lessons, viewing mathematics as uninteresting and difficult. I observed that many schools in the community where I taught lacked access to adequate teaching and learning materials, which motivated me to establish an organization called Mickinet Systems to help distribute these resources free of charge.

Motivated by a desire to improve my teaching practice and deepen my expertise, I enrolled in an undergraduate program in mathematics education at the University of Education, Winneba, one year into my teaching career. During my studies, I continued teaching mathematics at Akoteykrom No.1 D/A Basic School, balancing my academic and teaching responsibilities. My B.Ed. program equipped me with a robust foundation in mathematical content knowledge, pedagogical strategies, and principles of basic education. As part of my studies, I conducted action research focused on understanding and addressing student difficulties in fractions, which sparked my interest in exploring misconceptions and myths in mathematics learning—a recurring issue I had encountered over the years.

My passion for mathematics education led me to pursue further studies at the University of Manitoba, where I began a Master of Education program in mathematics education in 2022. Throughout my M.Ed. program, I gained new perspectives through courses in curriculum inquiry, study of teaching, qualitative research, and mathematics tasks and research issues. Additionally, my work as a research assistant further honed my research skills and deepened my understanding of educational inquiry.

Before my M.Ed. studies, my teaching approach in Ghana was largely grounded in a behaviorist approach. As a new teacher, I relied heavily on direct instruction and structured drills, which often resulted in shallow understanding of mathematics concepts. Students memorized procedures without grasping the underlying concepts, leading to difficulties when they encountered problems that required deep thinking or application of mathematics concepts.

However, my exposure to the constructivist learning theory at the University of Manitoba reshaped my educational philosophy. This shift in perspective has since influenced my approach to teaching and forms the foundation of this study. I now view mathematics learning as an

engaging, student-centered experience that flourishes in an environment fostering exploration and deep understanding, rather than mere memorization (Charles, 2020).

My education and professional journey has informed my interest and engagement in this study. My experiences as a classroom teacher informed my understanding of the misconceptions and myths students face in mathematics learning. This background motivated me to explore these misconceptions and myths, as I recognized their impact on student learning and engagement. Furthermore, my exposure to constructivism influenced me to focus on the important components of constructivism—teacher, students and environment (Charles, 2020). These components serve as a lens through which I collected and analyzed the data. The components of constructivism and how each impact mathematics learning is discussed in Chapter Two.

Structure of the Thesis

This thesis explores teachers' perspectives on the misconceptions and myths that basic school students have about mathematics learning. Specifically, the research examines the case of one school in Ghana and explores the misconceptions and myths teachers believe students in the selected school have about mathematics learning. Chapter One introduces the study by presenting the context of education in Ghana, highlighting the education reforms and structure of pre-tertiary education in Ghana. I also presented the research problem and research questions that guide the study. Additionally, I discussed my background as a researcher and its influence on my perspective and approach to this study.

Chapter Two focuses on a review of the literature relevant to this research and presents the theoretical framework for the study. I reviewed previous studies on mathematics misconceptions and myths and present the theoretical framework that provided the lens through

which this study was conducted. I also describe the research model that shaped the data collection and analysis process, establishing a foundation for this study.

Chapter Three details the methodology and methods used in conducting the study. I describe the study's qualitative methodology, explain the choice of a case study design along with qualitative methods such as interviews and observations. I discuss the strengths and limitations of the methodology and methods, describe how the data was collected and the steps used to analyze the data. The chapter also addresses some ethical considerations and my positionality, outlining measures taken to minimize researcher bias.

Chapter Four presents the findings of the study. I present the case of the selected school using three pre-determined themes derived from the theoretical framework. I also examine teachers' views about students' misconceptions and myths to supplement the observational data gathered from the classroom.

In the final chapter, Chapter Five, I discuss the study's findings in relation to each research question. I present key findings and how they add to existing literature. I discuss whether the findings agree or differ from the literature reviewed in Chapter Two and other related studies. I also discuss the implications of the findings and limitations of the study and outline potential directions for future research, building on the knowledge gained through this study.

Chapter 2: Literature Review and Theoretical Framework

This chapter provides an overview of literature that supports the study and the theoretical framework that served as a lens through which the study is framed. Before reviewing the literature that supports the study, I explain the literature review process, including the databases and keywords used, and how I selected the literature I chose to include in this review.

The Literature Review Process

In conducting the literature review, I undertook a comprehensive search to identify studies specifically focusing on misconceptions and myths in mathematics education, with a particular interest in research conducted in educational contexts similar to Ghana. I used various databases and included keywords such as *misconceptions*, *myths*, *mathematics education*, *basic school*, *middle school*, and *Ghana*. I selected studies based on their relevance to the research questions and the insights they offered into the prevalence, origins, and impacts of misconceptions and myths in mathematics learning.

Initially, I searched databases such as ERIC, Google Scholar, and ProQuest using relevant keywords. Additionally, I used citation chaining to identify related topics from the references of retrieved articles. After the initial search, I screened the retrieved articles based on their titles and abstracts to determine their relevance to the research question. Only studies related to mathematics learning and those that focused on misconceptions and myths in mathematics education were included in the review. I assessed the suitability of selected articles for inclusion in the literature review by engaging in a full-text review.

Misconceptions in Mathematics Teaching and Learning

Despite the extensive literature on mathematics education, there is a relative scarcity of studies examining misconceptions among basic school students in the Ghanaian context.

However, several studies from diverse regions have provided valuable insights into the nature and effects of misconceptions in mathematics learning. For instance, studies conducted by Kshetree et al. (2021), Stothard (2021), Ocal (2017) and Jamaludin and Maat (2020) shed light on the prevalence of misconceptions among students and the challenges they pose to effective mathematics learning. Reviewing these studies provided a foundation for exploring teachers' perspectives on the misconceptions prevalent in mathematics learning among Ghanaian basic school students.

Misconceptions in mathematics learning are pervasive and can hinder students' understanding and performance (Kshetree et al., 2021). Researchers and mathematics teachers have expressed concern about these challenges. Kshetree et al. (2021) highlight that misconceptions must be identified and dispelled before meaningful learning can take place. This is because, misconceptions arise from incorrect notions and a lack of clarity in concept acquisition, and if left unaddressed, they persist, impeding students' ability to learn mathematics effectively. Hence, for students to build a solid foundation in mathematics, it is important for teachers to identify and clear up misconceptions, facilitating meaningful learning experiences (Kshetree et al., 2021).

The study by Kshetree et al. (2021) was conducted with eighth-grade students in Nepal. It found a relationship between the pedagogical approach used by teachers and students' misconceptions. The study compared the results of two groups: the control group, which received conventional teaching using traditional methods, and the experimental group, which received a guided teaching approach specifically designed to address students' misconceptions and errors. The findings showed that the guided teaching approach used in the experimental group was effective in reducing and correcting students' misconceptions and errors in

mathematics. This suggests that the approach used by teachers plays a role in either reinforcing or addressing students' misconceptions.

While the study by Kshetree et al. (2021) provides valuable insights into the effectiveness of guided teaching in addressing misconceptions, it lacks a deep exploration of the factors contributing to these misconceptions. The study focuses primarily on intervention outcomes but does not analyze potential influences such as socio-cultural factors and students' prior knowledge. Considering these underlying factors could lead to more effective interventions.

The importance of addressing misconceptions was also emphasized by Jamaludin and Maat (2020). They conducted a systematic review of 30 studies written in English, published between 2014 and 2019, focusing on misconceptions in mathematics among students. The studies spanned various contexts, including misconceptions in numbers (Durkin & Rittle-Johnson, 2015; Lin, 2016), geometry (Ozkan & Bal, 2017), fractions (Uzel, 2018), and measurement concepts such as length, area, and volume (Sisman & Aksu, 2016), all within primary school settings. However, the overall review also included studies from other educational levels such as secondary, college, and university. Their review highlighted the importance of identifying and addressing misconceptions early in students' educational journeys. Although Jamaludin and Maat (2020) used a systematic review approach and Kshetree et al. (2021) employed an experimental design, the studies complement each other by emphasizing the significance of early intervention in mathematics learning.

Stothard (2021) presents a reflective analysis of how mathematical misconceptions can develop and persist in primary education. Drawing on personal experiences teaching primary school students aged six and seven, the author illustrates how educators may unintentionally reinforce misconceptions. Stothard (2021) reflects on their pivotal teaching moment where a

teacher's statement such as *You cannot halve three* may have introduced a misconception about division in mathematics. Although the intent of the teacher here was to explain that halving three does not result in a whole number, the phrasing misled students and perpetuated a misunderstanding (Stothard, 2021, p. 37). Stothard (2021) concludes that teachers can disseminate misconceptions through their language and teaching practices unintentionally. Unlike the more structured approaches of Kshetree et al. (2021) and Jamaludin & Maat (2020), Stothard (2021) adopts a narrative method to emphasize the role of teaching practices in perpetuating misconceptions. Stothard (2021) highlights how visible errors often signal deep, underlying misconceptions, suggesting the need for reflexive teaching practices and professional development.

Misconceptions represent significant gaps in understanding, distinguishing them from errors or mistakes (Stothard, 2021). While errors may result from miscalculations or carelessness (Jamaludin and Maat, 2020), they can also signal underlying misconceptions that remain undetected for extended periods (Stothard, 2021). Jamaludin and Maat (2020) note that misconceptions result from unchecked misunderstandings which may manifest as errors in students' work. Both studies (Jamaludin and Maat, 2020; Stothard, 2021) agree on the need for proactive identification and correction of misconceptions to prevent their persistence and the resultant negative impacts on students' mathematics learning. They highlight the interconnected nature of errors and misconceptions, advocating for deliberate instructional strategies to effectively uncover and address these issues.

Ocal (2017) examined asymptote misconceptions in a university-level calculus classroom in the eastern part of Turkey, comparing the use of GeoGebra graphing software with traditional teaching methods. This multiple case study involved two student groups and found that while

GeoGebra facilitated a slight improvement in understanding, many students continued to struggle with conceptualizing the behaviour of functions near asymptotes. Although the context and participants of Ocal's (2017) study differ significantly from those in the studies of Jamaludin and Maat (2020), Kshetree et al. (2021) and Stothard (2021), all four studies (Stothard, 2021; Kshetree et al., 2021; Jamaludin & Maat, 2020; Ocal, 2017) agree that misconceptions in mathematics could hinder learning and must be addressed to foster a deep understanding of mathematics concepts. Each study highlights the important role of teachers in addressing the misconceptions students have about mathematics learning.

Research has identified several misconceptions and explored various strategies to address them. Students often misinterpret concepts such as fractions, decimals, and negative numbers (Siegler & Lortie-Forgues, 2015). For instance, they might believe that a larger denominator means a larger fraction (Siegler & Lortie-Forgues, 2015). This misunderstanding can lead to significant errors in more complex mathematical tasks.

Another prevalent issue is the focus on procedural knowledge over conceptual understanding. Many students memorize procedures without grasping the underlying concepts, which can result in difficulties when they encounter non-routine problems (Rittle-Johnson & Schneider, 2015). This procedural approach can limit their ability to apply mathematical principles flexibly and accurately (Rittle-Johnson & Schneider, 2015). It can also impact their ability to connect new knowledge with existing understanding (Jankvist & Niss, 2018). According to Van de Walle et al. (2013), the overemphasis on procedures rather than concepts is a significant contributor to persistent misconceptions. Consequently, students may struggle to develop a deep understanding of mathematical principles and fail to transfer knowledge effectively to new contexts (Van de Walle et al., 2013). From a constructivist perspective,

learning is most effective when learners actively construct their own understanding by linking new information to prior knowledge and engaging in meaningful problem-solving (Bada & Olusegun, 2015; Schunk, 2012). Thus, the overreliance on rote procedures contradicts the constructivist emphasis on deep, conceptual learning. Constructivism advocates for learning environments where students explore, question, and reflect, rather than simply follow procedures. Addressing this procedural focus by emphasizing conceptual understanding is one important means of overcoming misconceptions.

According to Van de Walle et al. (2013), overgeneralization is a common problem as students may apply rules too broadly. For instance, students may assume all functions are linear or that the properties of whole numbers apply to all numbers (Van de Walle et al., 2013). The Learning Agency Lab (2023) also notes that misconceptions often arise from students' attempts to fit new information into existing schemas, even when it does not fit well. While overgeneralization could lead to incorrect conclusions and hinder students' ability to understand more advanced mathematical concepts (Van de Walle et al., 2013), I believe it offers insights into how students are constructing meaning. From a constructivist standpoint, students can explore and try out new ideas freely (Acar & Yılmaz, 2015). As students explore and try new ideas, they may make errors and overgeneralize. I opine that this is part of the learning process as it offers students the opportunity to re-evaluate their assumptions to recognize inconsistencies and eventually restructure their understanding. Hence, overgeneralization should not only be seen as a result of misconception but also as an opportunity for reflection and re-evaluation to deepen conceptual understanding.

Myths in Mathematics Teaching and Learning

Myths in mathematics teaching and learning are beliefs that shape students' perceptions and attitudes towards the subject, often hindering their academic growth and limiting their potential (Chestnut et al., 2018). Myths about mathematics teaching and learning are not confined to students alone; they are often shaped by societal beliefs and reinforced by teachers, parents, and the broader community. These widely held myths can influence how students perceive their capabilities and how they are treated in educational spaces. At their core, such myths often reinforce exclusionary narratives that hinder student potential and perpetuate inequality in mathematics education (Chestnut et al., 2018).

One widely held myth is the association of mathematics with brilliance (Chestnut et al., 2018). Many people believe that only a select few students can excel in mathematics due to its complexity (Chestnut et al., 2018). This notion can deter students from pursuing mathematics-related courses and create barriers to success, especially for those not perceived as naturally brilliant (Franz et al., 2016).

There is a widely held belief that some individuals are math people, while others are not (Franz et al., 2016). This belief can foster a fixed mindset in students, leading them to feel that success in mathematics is unattainable without innate talent (Chestnut et al., 2018). As a result, students may avoid engaging with the subject altogether, limiting their opportunities for growth and achievement in mathematics. I believe challenging this myth may help create a more inclusive learning environment, where all students can develop their mathematical abilities and pursue success, regardless of their perceived natural aptitude.

There is also another widely held belief linking mathematical ability to race and gender. Sheffield (2017) identified the myth that people who excel in mathematics are typically Asian or

White males, while women and Black people are often stereotyped as not suited for mathematics. However, Leyva (2017) found no correlation between gender or race and performance in mathematics. This stereotype could discourage marginalized groups from pursuing mathematics. Research by Fennema et al. (1990) shows that cultural factors contribute to the belief that gender or race is linked to mathematical ability. For instance, female students' success is often attributed to hard work, while male students are viewed as naturally gifted (Fennema et al., 1990). Similarly, Yarkin et al. (1982) note some people attribute the excellent performance of racial and ethnic marginalized groups to institutional support or extra effort rather than individual capability. These contribute to existing racial and gender stereotypes in mathematics (Chestnut et al., 2018) and may cause bias among teachers, professors, and employers (Koch et al., 2015).

These myths, particularly those linking success in mathematics to brilliance or specific racial and gender groups, are incompatible with the constructivist view of learning. From a constructivist perspective, the learning environment plays an important role in shaping how students engage with mathematical ideas. The environment includes not only the physical classroom but also the broader sociocultural context, including students' experiences, beliefs, and interactions (Davis, 2016; Duedu et al., 2005). When the environment is shaped by gender and racialized stereotypes, it may marginalize students and discourage full participation (Leyva, 2017).

The Impact of Prior Knowledge on Misconceptions and Myths

Prior knowledge plays a pivotal role in shaping students' understanding of new mathematics concepts. Zakariya et al. (2021) highlight that students with a solid foundation in mathematics tend to perform better and approach learning more effectively. Conversely, gaps in

prior knowledge can hinder students' ability to understand new concepts, which could lead to misconceptions and myths. Similarly, Chen et al. (2018) note that students with low prior knowledge often face greater challenges in understanding mathematics, as their foundational gaps make it harder to integrate new ideas, potentially fostering the perception that the subject is difficult. This highlights the importance of prior knowledge, as it provides the context for understanding new material. When foundational knowledge is incomplete or incorrect, students may misinterpret concepts, rely on rote memorization, or develop flawed problem-solving strategies (Chen et al., 2018). These problems may persist over time, impacting future learning.

To address this, teachers should not only identify and remediate gaps in prior knowledge but also employ strategies that actively connect new material to students' existing understanding (Chen et al., 2018). Encouraging meaningful engagement, as noted by Zakariya et al. (2021), and implementing supportive interventions (Chen et al., 2018) can help students overcome foundational deficits in mathematics. By bridging gaps in prior knowledge and fostering meaningful connections between new and existing concepts, teachers can create a more inclusive and effective learning environment.

Building on the importance of addressing misconceptions and myths in the teaching and learning of mathematics, this study explores teachers' perspectives of the misconceptions and myths held by Ghanaian students through the lens of constructivism.

Theoretical Framework

This study is grounded in constructivism, and in this section I discuss the relevant theoretical underpinnings, the tenets of constructivism relevant to this study, and the research model used to focus data collection and analysis.

Theoretical Underpinnings

Constructivism is a learning theory which emphasizes the importance of students actively participating in developing their knowledge and understanding rather than passively receiving information from teachers (Bada & Olusegun, 2015; Schunk, 2012). This theory values inquiry and experimentation, encouraging learners to question and critique information for a deeper understanding. There are several types of constructivism, such as cognitive (Piaget, 1977), social (Vygotsky, 1978), and radical (von Glasersfeld, 1995). This study focuses on cognitive and social constructivism.

Cognitive Constructivism. Cognitive constructivism (Piaget, 1977) involves individuals actively constructing their understanding through mental processes. Piaget (1977) asserts that learning occurs by achieving equilibrium between existing schemas and new information, a process known as equilibration. This involves assimilating and accommodating new information to resolve mental dissonance (Piaget, 1977).

Assimilation and accommodation are key processes in cognitive development, as described by Piaget (1977). Assimilation involves integrating new knowledge or experiences into pre-existing mental models or structures, known as schemas (Piaget, 1977). This process allows individuals to expand and improve their current schemas, thereby broadening their perspectives on reality. By doing so, they can make sense of their surroundings using the knowledge they now possess. Assimilation occurs when a person takes in new knowledge without needing to modify their prior understanding of an idea (Piaget, 1977).

On the other hand, accommodation occurs when individuals modify their cognitive schemas or mental frameworks to incorporate new information or experiences that do not fit their current understanding (Piaget, 1977). In other words, the individual adjusts what they already know about a concept to make sense of new information related to that concept.

Together, these processes enable individuals to continuously adapt and refine their understanding of the world around them.

Social Constructivism. Social constructivism asserts that communication and the environment shape knowledge in social contexts (Vygotsky, 1978). It implies that people actively shape how they perceive the world through their interactions with others and cultural environments.

Vygotsky (1978) distinguished between two types of concepts that children acquire through engaging with others: spontaneous concepts and scientific concepts. Spontaneous concepts are those that children develop naturally through their everyday experiences and social interactions (Vygotsky, 1978). These are often informal and intuitive understandings that arise from engaging in daily activities, such as a child learning basic arithmetic concepts, such as more and less, during mealtimes.

In contrast, scientific concepts are structured, formal understandings typically introduced in educational settings through guided instruction (Vygotsky, 1978). These concepts are deliberately introduced and facilitated by teachers and often involve abstract reasoning, systematic thought, and the use of specific terminologies, such as learning about the principles of geometry (Vygotsky, 1978). Vygotsky emphasized that scientific concepts build upon spontaneous ones, enabling a deeper understanding of concepts. Scientific concepts indicate the teacher's role in bridging the dynamic interaction between informal learning from life experiences and formal learning in educational settings to achieve a holistic understanding of mathematics concepts.

Another important aspect of social constructivism is collaboration (Vygotsky, 1978). According to Vygotsky, students can build scientific concepts through collaboration with a more

knowledgeable individual. Vygotsky believed it is very beneficial when collaboration comes from working inside a student's Zone of Proximal Development (ZPD) with a teacher or another more knowledgeable individual. The ZPD refers to the range of tasks or activities that a learner can perform with the help or guidance of a more knowledgeable person, such as a teacher (Vygotsky, 1978). It represents the area where the most sensitive instruction or guidance should be provided, enabling a learner to develop skills they will later use independently. The ZPD encompasses tasks that lie just beyond a learner's current abilities but can be accomplished with the help of a more knowledgeable other (MKO), such as a teacher, peer, or mentor. This concept emphasizes that learning is most effective when it occurs within this range, as the learner is not overwhelmed by unattainable tasks. For example, a child learning to solve a mathematics problem might initially require the MKO to explain the steps or provide hints. Over time, with repeated practice and decreasing support, the child may solve similar problems independently, thus moving beyond the ZPD for that specific skill. The effectiveness of the ZPD lies in the careful and intentional guidance provided by the MKO, which helps learners progress from dependence to independence in their understanding and skills (Vygotsky, 1978).

While teachers often serve as the MKO, collaboration among learners also plays an important role in learning. Vygotsky emphasized that learning is a social activity, and as such, students could also act as MKOs for one another. Through collaborative learning, peers provide explanations, share strategies, and work together to solve problems, reinforcing each other's understanding. For instance, when a student struggling with a mathematical concept engages in a discussion with a more proficient peer, the exchange of ideas could help deepen understanding of the concepts. The dynamic process of working within the ZPD, whether guided by a teacher

or a peer, can promote meaningful learning experiences that build confidence in learning gradually (Vygotsky, 1978).

Vygotsky's theory leads to the concept of scaffolding (Bruner, 1983). Scaffolding operationalizes Vygotsky's theory by detailing how support can be structured and gradually withdrawn to maximize learning within the ZPD. Bruner (1983) defines scaffolding as the temporary support provided by a teacher or knowledgeable other to help learners perform tasks just beyond their current abilities. In mathematics education, scaffolding effectively guides students through complex concepts by modeling processes, breaking problems into manageable parts, and offering prompts instead of direct solutions. For instance, when teaching complex equation solving, a teacher might support students by modelling the process, offering prompts or hints instead of direct solutions, encouraging reliance on their reasoning and prior knowledge. An important aspect of Bruner's theory is the gradual removal of these support as learners gain proficiency in the concepts. This approach could empower learners to build competence and confidence in the mathematics concept, highlighting the importance of adaptive teaching to support students in their mathematics learning.

Both cognitive and social constructivism emphasize the significance of three key elements: the teacher, the students, and the environment (Charles, 2020). For meaningful learning to occur, these components must be effectively integrated (Charles, 2020). I posit that if these three tenets are not carefully managed during the teaching and learning of mathematics, the classroom may become an environment where misconceptions and myths are unintentionally reinforced rather than challenged and addressed through guided learning.

Three Tenets of Constructivism: The Teacher, The Students, and The Learning Environment

The Teacher. Teachers facilitate the learning process in a constructivist class rather than just imparting information to the students. They create meaningful tasks for students to engage with (Stein et al., 2009). Teachers need to observe students while they work on tasks, help them with follow-up questions, assess their learning, and provide insightful feedback in a timely manner. Without these activities, learning is likely to be less meaningful and focused (Stein et al., 2009). The constructivist theory advocates for learner-centred instruction, where learners actively construct their knowledge instead of receiving information passively (Major & Mangope, 2012). In a constructivist classroom, teachers encourage students to ask questions, engage in critical thinking, and participate in collaborative activities (Acar & Yılmaz, 2015). They also provide opportunities for students to engage in problem-solving and reflect on their thinking to enhance learning (Acar & Yılmaz, 2015).

The Students. Students in a constructivist class are active learners. Student engagement is fundamental to constructivist learning (Bada & Olusegun, 2015). Constructivist theorists argue that students construct knowledge when they engage actively in cognitive tasks through collaboration with their peers and teachers (Piaget, 1977). In other words, students construct knowledge through their interactions with other students and the environment (Major & Mangope, 2012). They engage with the tasks created by the teacher and make meaning out of them based on their experiences (Piaget, 1977; Stein et al., 2009). In addition, students are allowed to explain their views, ask questions, and respond to questions from the teacher and other students (Piaget, 1977; Vygotsky, 1978). This makes learning interactive and meaningful. Students are encouraged to be actively involved in the learning process, making connections to prior knowledge and real-life experiences (Acar & Yılmaz, 2015).

Active student engagement is important because it promotes ownership of learning and motivates students to learn (Major & Mangope, 2012). When students are actively engaged, they become more invested in their education, leading to improved learning outcomes (Major & Mangope, 2012). By actively engaging in tasks and participating in discussions, students take ownership of their learning, transforming the classroom into an interactive and dynamic atmosphere where meaningful learning takes place. This engagement could promote deep understanding, higher-order thinking skills, and the ability to transfer knowledge to new situations (Acar & Yılmaz, 2015).

The tasks designed by the teacher influence the level of student engagement in the classroom (Stein et al., 2009). Tasks should require meaningful engagement and encourage students to connect real-world experiences to mathematical principles (Stein et al., 2009). Meaningful student engagement goes beyond placing manipulatives in front of students. In their description of constructivist approaches to mathematics teaching and learning, Stein et al. (2009) assert that the kind and level of thinking that students apply to manipulatives determine how meaningful the engagement is for them. Hence, teachers need to be clear about their goals for student learning and the cognitive demands of tasks before selecting or creating tasks for students to engage with (Stein et al., 2009).

The Learning Environment. In a constructivist environment, the teacher provides a conducive learning atmosphere; however, students also share the responsibility of building and maintaining such an environment (Charles, 2020; Quintero & Rosario, 2016). A conducive and enabling environment encourages interaction among students (Quitero & Rosario, 2016). When students' views are respected, the environment is conducive to learning, and therefore, students are more willing to share and try out new ideas in such an environment (Charles, 2020). I agree

with Stein et al. (2009) and others that in a conducive and enabling environment, mathematics tasks are designed to allow for meaningful student engagement to develop conceptual understanding.

The learning environment should be supportive, inclusive, and respectful (Acar & Yılmaz, 2015). It should also promote communication and collaboration among students (Acar & Yılmaz, 2015). Students should feel comfortable expressing their ideas and should be able to engage in discussions without fear of judgment (Major & Mangope, 2012). A conducive environment allows for the free exchange of ideas, encourages active participation, and promotes a sense of belonging among students (Major & Mangope, 2012). Additionally, it fosters a positive learning atmosphere that enhances creativity, critical thinking, and problem-solving skills (Major & Mangope, 2012). I believe a conducive and supportive environment instills confidence in students and enables them to develop a love for learning.

From a constructivist standpoint, teachers play an important role in fostering an atmosphere that is free from fear and intimidation, as this encourages active participation and engagement (Langoban, 2020). An enabling environment allows students to share ideas, ask questions, and explore concepts without judgment (Acar & Yılmaz, 2015; Quintero & Rosario, 2016). In my view, creating a supportive and inclusive classroom environment may help in dispelling myths about mathematics learning. By fostering a learning space where all students feel safe and valued, teachers can help dismantle myths and promote a more inclusive and engaging experience in mathematics learning.

Therefore, this current study extends the concept of the environment beyond the classroom to include socio-cultural factors that may impact how students engage with mathematics tasks. Research has shown that sociocultural factors shape students' engagement

with mathematics tasks (Davis, 2016; Duedu et al., 2005). Language is one important socio-cultural factor that may impact how students engage with mathematics tasks (Boulet, 2007). For example, clear and precise communication from teachers could help students make meaningful connections to mathematics concepts, whereas ambiguous language could create confusion and hinder understanding (Boulet, 2007).

Incorporating students' home languages into instruction in multilingual and multicultural settings could enhance learning (Niesche, 2009). When students encounter mathematical ideas in a familiar language, they are more likely to relate to and understand them. Students may find it easier to transition from their everyday experiences to academic learning if they use their native language as a bridge to the formal language of mathematics. This will help them perceive mathematics as a relevant and approachable aspect of their life (Niesche, 2009). Therefore, integrating home languages into mathematics instruction could foster a more inclusive and empowering learning environment for learners.

Culturally responsive teaching strategies, such as integrating local out-of-school mathematical practices, have proven effective in promoting inclusivity (Davis, 2016; Hedegaard & Chaiklin, 2005). For example, traditional units like the *olonka* are commonly used in Ghana to measure cereals and grains. Incorporating these familiar units into classroom teaching can make learning more relatable and meaningful (Davis, 2016). This approach can help students to connect prior knowledge to new mathematical concepts, increasing their motivation and interest in the subject (Bright & Clement, 2003).

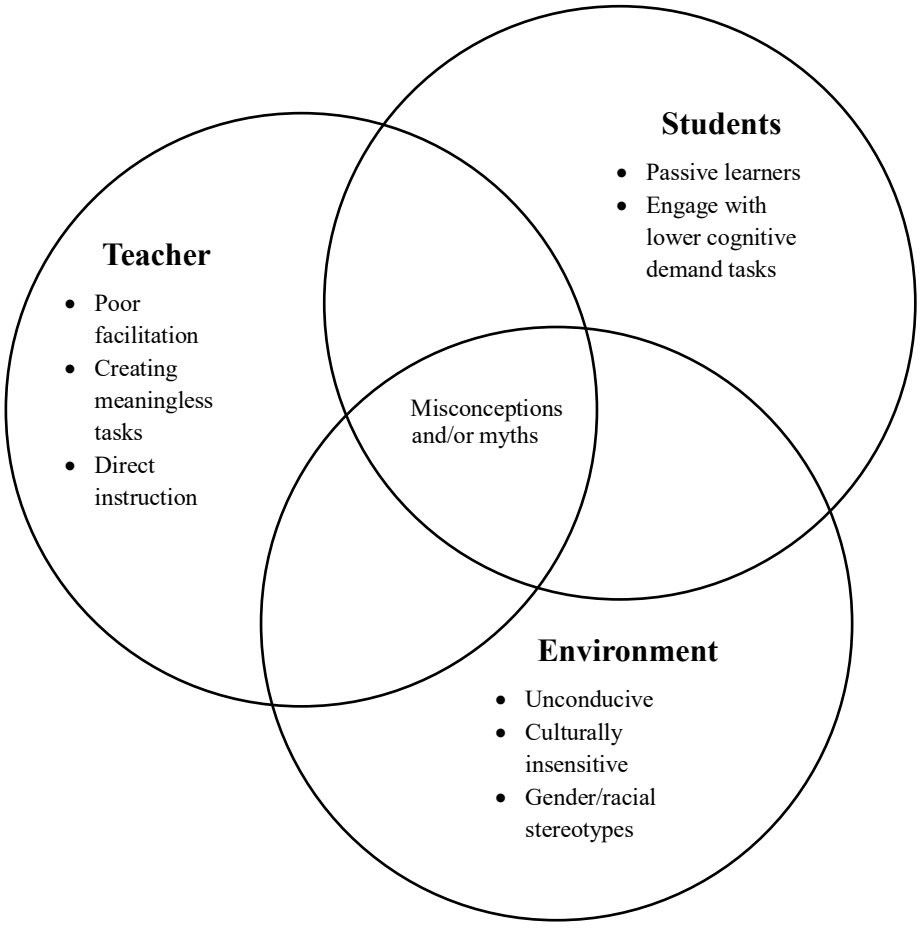
Integrated Teacher-Student Environment (ITSE) Research Model

I used the Integrated Teacher-Student Environment (ITSE) model (see *Figure 1*) to frame data collection and analysis for the study. The ITSE model is an adaptation of the research model

developed by Charles (2020), which aligns with constructivism. Charles' model positions the actions of the teacher, students' active participation, and a conducive environment (three tenets of constructivism) as equal factors in students' achievements and understanding of mathematics. In contrast, the ITSE model illustrates how students can develop misconceptions and myths if these three tenets of constructivism are not carefully managed in the teaching and learning of mathematics.

Figure 1

The ITSE Research Model



Note. Adapted from *Comparing the effects of two inquiry-based teaching strategies on secondary students' conceptual understanding and achievement in mathematics: A mixed-methods approach,* by C. Charles, 2016, pp. 41-42.

The model presents three roughly equal, interlocking sections arranged in a circle, each representing a key component—teacher, student, and environment—to indicate their equal impact on learning. The intersection of the three sections represents misconceptions and/or myths, indicating the shared and interconnected influence of these components. That is, I opine that the relationship between the teacher, students, and environment may impact students' misconceptions and myths about mathematics learning.

Regarding the teacher component, the ITSE model posits that poor facilitation—characterized by an overreliance on direct instruction, the use of meaningless tasks, and the failure to provide timely feedback—could contribute to the development of students' misconceptions about mathematics learning (Jankvist & Niss, 2018). When the teacher fails to facilitate learning effectively, students may struggle to grasp concepts, leading them to rely on flawed procedures (Stothard, 2021). That is, when teachers predominantly teach without engaging students in active exploration or meaningful dialogue, mathematical ideas could be presented in fragmented or overly abstract ways. This disconnected approach may limit students' ability to relate new concepts to prior knowledge or real-world experiences.

The student component of the ITSE model highlights that when students remain passive learners or are consistently engaged in tasks with low cognitive demand (Stein et al., 2009), they may develop misconceptions about mathematics learning. Tasks that require rote memorization do not promote meaningful learning (Stein et al., 2009). Without opportunities to engage

meaningfully with tasks, reflect on their thinking, or connect mathematical concepts to real-life contexts, students may construct inaccurate understanding of concepts (Stein et al., 2009).

Similarly, the environment component highlights that an environment that is culturally insensitive, unconducive, or shaped by gender and racial stereotypes could lead to the development of myths. When the learning environment is not conducive, lacking respect for students' views and failing to acknowledge their cultural identities, it may impact students' confidence to engage with tasks (Acar & Yılmaz, 2015). In such an environment, students may feel hesitant to share their thoughts, which could limit opportunities for discussions (Charles, 2020). Also, an unconducive environment fails to acknowledge the diverse backgrounds and experiences that students bring into the classroom (Acar & Yılmaz, 2015; Hedegaard & Chaiklin, 2005). This could further alienate learners and contribute to the development of myths and misconceptions, as students are not given the space or support to question, explore, or make meaningful connections in their learning.

In conclusion, I opine that misconceptions and myths in mathematics learning can emerge when the key tenets of constructivism—the teacher, students, and environment—are not effectively integrated. A breakdown or flaw in any of these elements may hinder students' understanding of mathematics concepts. Misconceptions may arise when there is poor teacher facilitation, passive student engagement and an unconducive environment. For example, if teachers fail to facilitate learning properly or fail to provide a supportive environment for learning, students may likely develop misconceptions about mathematics learning.

Similarly, myths about mathematics learning can develop when the integration of the teacher, students, and environment is ineffective. For example, I believe if teachers do not create an inclusive and supportive classroom culture, students may internalize myths such as the belief

that mathematics is difficult and exclusive to the gifted and intelligent. Additionally, when teachers do not encourage active learning and critical thinking, I believe students may develop or reinforce their belief in the myth that mathematics is about memorization of procedures rather than understanding.

To address both misconceptions and myths, I believe it is important for the three tenets—teacher, student, and environment—to be effectively integrated. Teachers can actively engage students, challenge stereotypes, and create an inclusive learning space that encourages critical thinking and reflection. By ensuring that these components work together harmoniously, teachers can help students develop a sound understanding of mathematical concepts while minimizing the impact of misconceptions and myths.

Summary

In this chapter, I reviewed some of the literature on misconceptions and myths in mathematics learning, highlighting the role of prior knowledge and how it might affect teachers' perceptions about students' misconceptions and myths. I also presented the theoretical framework of constructivism, which underpins this study. I further discussed the ITSE model, adapted from Charles's (2020) research, which emphasizes three key tenets—teachers, students, and the environment—and how each of these tenets impacts the development of misconceptions and myths in mathematics learning.

Chapter 3: Methodology and Methods

This research examines teachers' perspectives about misconceptions and myths that basic school students in Ghana may hold about mathematics learning. The research explores the following questions: (a) What are teachers' perspectives on the misconceptions and myths that basic school students in Ghana exhibit in their mathematics learning? (b) What factors do teachers perceive as contributing to the development and persistence of these misconceptions and myths among basic school students in Ghana? To investigate these questions, I implemented a case study research design using qualitative methods to collect data from the participants. This chapter is structured into five main sections to describe the methodology and methods used and factors that might have affected their use. The first section provides a discussion of the research design. The second section describes the case and research participants in detail. The third section elaborates on the data collection methods employed. The fourth section outlines data analysis processes utilized. And the final section addresses ethical considerations.

Research Design

This study employs qualitative research to explore teachers' perspectives on Ghanaian basic school students' misconceptions and myths about mathematics learning. I employed qualitative research methods because they focus on understanding meaning and processes rather than measuring outcomes (Merriam & Tisdell, 2016). These methods allowed me to explore participants' interpretations of their experiences and views on students' misconceptions and myths about mathematics learning. By prioritizing the perspectives of participants, I was able to gain deeper insights into the lived experiences and social dynamics that shape these misconceptions and myths.

I utilized a qualitative case study design which facilitated an in-depth examination of the unique contextual factors pertinent to the selected case (Yin, 2014). The study focused on a single basic school in Ghana, chosen as the case for its specific relevance to the research objectives. The participants included mathematics teachers and some selected students from the same school, with the primary aim of investigating teachers' perspectives on the misconceptions and myths held by students regarding mathematics learning.

I used convenience sampling (Golzar et al., 2022) to identify and select participants based on practical considerations, particularly their accessibility and proximity to me. I chose the school due to its location near my accommodation, which minimized logistical challenges related to travel and data collection. Choosing this school streamlined the data collection process, ensuring efficient use of resources and adherence to the study's timeline.

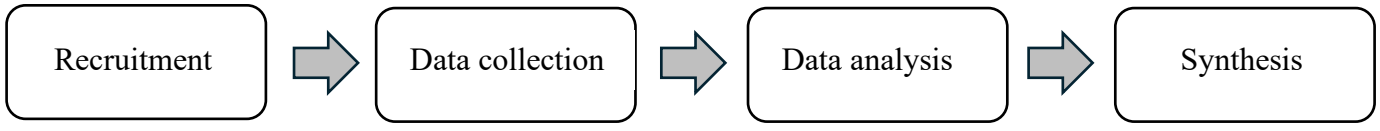
To explore the selected case, multiple data collection methods were employed, including individual interviews, focus group discussions, and classroom observations of mathematics lessons. I chose these methods to capture a holistic understanding of the teachers' views and the students' learning experiences within the specific educational context of the selected school.

Phases of Research Activities

The study involved four phases—recruitment, data collection, analysis, and synthesis (See *Figure 2*). These phases ensured the study was conducted in a thorough and ethical manner.

Figure 2

Summary of Research Activities



Note. This diagram illustrates the sequential steps taken in the research process.

I present a description of each of the phases below.

Recruitment Phase. The recruitment phase involved several preliminary steps aimed at securing the necessary permission and consent to conduct the study. I began by writing to the Adentan Municipal Directorate to obtain formal authorization to carry out research in one of the schools within their jurisdiction. Upon receiving written approval, I sent an invitation letter to the head teacher of a school located near my accommodation, requesting permission to partner with mathematics teachers in grades 7 to 9 for the study.

After receiving verbal approval, the head teacher helped me identify teachers of mathematics in the school. I provided them with a brief overview of the study, outlining its purpose, scope, and what their participation would involve. Consent forms were distributed to teachers who expressed verbal interest in the study, and they were given approximately three days to review the consent form and decide whether they wished to participate. Teachers were informed that expressing interest did not obligate them to participate in the study, and those who opted in were asked to sign and return the consent form through email.

After teacher consent was obtained, I spoke to students verbally, offering a clear overview of the study, their rights as participants, and emphasizing the voluntary nature of their participation. With the help of the teachers, students were selected based on their performance in mathematics from the previous term, as detailed further in the student participants section of this chapter. The selected students were given assent forms, which I read aloud and explained before inviting them to sign if they were willing to participate.

Next, parental consent was sought. With support from the head teacher and teachers, consent forms were distributed to the parents of the students who gave their assent. Parents were

encouraged to contact me via email if they required clarification before signing. After receiving signed parental consent forms, students were included in the study.

Data Collection Phase. The second phase of the research was data collection, during which I implemented a range of methods to gather data from the participants. These methods are described in detail in the data collection section of this chapter.

Data Analysis Phase. The data analysis phase involved steps for examining and analysing the collected data. This phase included steps such as coding the data, identifying emerging patterns, and organising the information under pre-determined themes. These steps were essential in making sense of the data and ensuring that the findings aligned with the study's research objectives. These steps are further detailed in the analysis section below.

Synthesis Phase. The final phase was data synthesis, during which I drew conclusions from the analysed data. At the beginning of this stage, I did member checking by sharing summaries of findings with teacher participants to confirm accuracy. I then explored the implications of the findings in relation to the research questions and the broader theoretical context of the study. These steps are also further detailed below.

Case Description: School Context

This case study focuses on a school located in a densely populated, multi-cultural urban community in Accra. The school serves a student population of about 900, ranging from kindergarten to Grade 9, with ages spanning from 5 to 18 years. The school employs about 45 teachers and is characterized by its diverse socio-economic and ethnic composition. Ethnically, the student population is diverse, with approximately 35% Ga, 30% Akan, 25% Ewe, and 10% from other ethnic groups. Each ethnic group speaks its unique Ghanaian language, reflecting the linguistic diversity of the students. Despite the linguistic diversity, English is used as the official

medium of instruction, in accordance with public school policies in Ghana. I obtained the demographic and institutional information through personal communication with the head teacher (Head Teacher, personal communication, October 3, 2024).

The school is situated in an urban community where most families engage in small-scale trading at local markets as their primary source of livelihood. The community faces a number of challenges, including limited access to healthcare, high crime rates, and unreliable public transportation according to community members that I spoke with. In response to the economic situation in the community, the head teacher explained that the school has established various support services, such as free breakfast programs, after-school tutoring and mentorship programs, counselling services, and partnerships with healthcare providers. Such initiatives aim to create an inclusive and nurturing learning environment for students. However, the school continues to face infrastructural constraints. Classrooms are extremely overcrowded, with more than 90 students in the Grade 7 class, 80 in Grade 8, and 100 in Grade 9. This level of overcrowding is very likely to impact effective individualized student attention. Furthermore, the school lacks a library, depriving students of access to essential reading.

Teacher Participants

The selection of teacher participants was based on their willingness to participate. After receiving verbal approval from the school administration to conduct the study, I approached six mathematics teachers available in the school and invited them to participate. Out of the six, four teachers expressed interest in taking part in the study. Thus, this study involved four mathematics teachers, comprising three males and one female who were teaching mathematics in the same school. All four teacher participants held Bachelor of Education degrees and had received professional training in mathematics education at one of the Colleges of Education in Ghana.

The teaching experience of the four teachers varied as follows. Teacher A taught mathematics to grade 8 students and had 20 years of experience; Teacher B taught grade 9 students and had 21 years of teaching experience; Teacher C taught mathematics to grade 7 students and had 19 years of teaching experience; and Teacher D taught grade 9 students and had 8 years of teaching experience. Teachers A, B, and C were males, while Teacher D was female. All four teachers who expressed interest provided informed consent by signing the consent form before they were included in the study.

Student Participants

Eighteen students participated in this study. The demographic details of the student participants included 12 females and 6 males, with ages ranging from 12 to 17 years. The student participants were selected to represent diverse abilities based on achievement levels. The achievement levels were determined based on their mathematics grades from the previous term, as recorded in the school-based assessment (SBA) records. Students who obtained a grade A or B were categorized as high achievers, those with a grade C or D were categorized as moderate achievers, and those with grades E or F were categorized as low achievers. Six students were selected from each of Grades 7, 8, and 9. Of the six students selected in each grade, two were high achievers, two were moderate achievers, and two were low achievers. This brought the total number of student participants to 18, where six were high achievers, six were moderate achievers, and six were low achievers. Each grade level included four female and two male students.

Data Collection

For data collection, I employed different methods tailored to each participant group. Teacher participants were engaged through individual interviews and a focus group discussion,

and I observed two mathematics lessons from each grade. All interviews were audio-recorded to facilitate accurate transcription and subsequent analysis. The student participants were only observed during mathematics lessons and did not participate in interviews. I took handwritten field notes to document my observations during classroom observations. I limited my observation notes to the interactions of the 18 students who had provided assent and parental consent. I conducted the classroom observations first, followed by individual interviews and then a focus group discussion. Below, I provide a detailed discussion of the data collection methods employed.

Classroom Observation

I conducted non-participant observations (Kumar, 2022) in mathematics classrooms to systematically document instructional strategies, student engagement, and classroom interactions. I used observation because it provided me with direct access to behaviour as it occurs, eliminating the reliance on self-reports (Kumar, 2022). I gained a deeper understanding of classroom interactions in their natural settings. The non-participant observation approach, which involves observing without engaging in classroom activities, ensured that regular classroom activities were not disrupted (Kumar, 2022; Pretzlik, 1994). I positioned myself at the back of the classroom, allowing me to observe without interfering with normal class routines. This seating arrangement enabled me to take detailed notes while allowing the teaching and learning activities to proceed naturally.

Observations were carried out in Grades 7, 8, and 9, with two lessons observed in each grade. These observations were conducted over the course of one week, following the school's regular timetable. Since mathematics was scheduled at least twice a week for each grade, I used these designated periods to observe two full lessons per grade. Each lesson was about 60 minutes

long. To identify the six student participants in each classroom who had provided assent/consent to participate, I used name tags labelled Student A to R. These name tags were affixed to the backs of the students' chairs, allowing me to clearly identify them from my position at the back of the classroom. Each observation lasted approximately one hour. I recorded only the interactions of the students who had provided assent/consent.

The mathematics concepts that teacher participants taught during these classroom observations—such as operations with measurements, algebraic simplification, and the use of mathematical symbols—were not new to the students. According to the Ministry of Education mathematics standards-based curriculum for Grade 4-6, these concepts are introduced in earlier grades at the primary level (Ministry of Education, 2019). For instance, operations with different measurement units and algebraic expressions with different variables and terms are introduced as early as Basic 5 and 6 and are reinforced through Basic 7 and 9.

I focused my observation on the instructional methods teachers employed, the engagement levels, responses, and interactions of the student participants, as well as the overall learning environment. To guide my observations and support the development of field notes, I created a template that documented the duration of the lesson and observations related to teacher facilitation, student engagement, and the overall classroom environment. Table 2 presents the structure of this observation guide, which was used to organize my field notes for each lesson.

Table 2

Structure for Classroom Observation

Grade	Overview of Activities	Teacher Facilitation	Student Engagement	Classroom Environment	Duration

I structured the observation template based on key components of the ITSE model and constructivist principles, which emphasize the interplay between teachers' instructional methods, student participation, and the learning environment. I used the Teacher Facilitation column to document how the teacher facilitated the lesson such as using direct instruction or another form of faciliation. For instance, I recorded teachers' instructional strategies, such as questioning techniques and how they created tasks for learning.

The Student Engagement column documented the engagement levels of the student participants during the lesson including the extent to which students actively participated in the lesson. I documented whether they asked questions, participated in group work, interacted with manipulatives and engaged in problem solving.

In the Classroom Environment column, I recorded observations related to the overall classroom atmosphere to determine whether the classroom was conducive. For instance, I recorded the overall physical environment, including whether the classroom was overcrowded. I also recorded whether students were encouraged to express themselves freely during the lesson.

The Overview of Activities column was used to summarize the main learning activities or topics of the lesson, such as problem-solving activities. This structure provided a guide for documenting events as they unfolded during the lesson and served as the basis for the observation findings.

Individual Interview

I conducted individual interviews (Kruger et al., 2019) with each of the four teacher participants after completing the classroom observations to gain a deeper insight into their

personal thoughts and experiences regarding misconceptions and myths in mathematics learning. Teacher A was interviewed first, followed by Teacher B, then Teacher C, and Teacher D. Each individual interview lasted approximately one hour.

At the start, I informed participants that the interview session would be audio recorded. I began the interview by welcoming participants and provided a brief explanation of the study's objectives. Before proceeding with the interview questions, I initiated a discussion about the concepts of misconceptions and myths. I presented the definitions of *misconception* and *myth* as presented in Chapter 1 and encouraged a brief discussion to work toward a shared understanding of these terms.

Next, I informed the participants of the voluntary and confidential nature of their participation. I reminded participants of their rights, such as their right to withdraw at any time during the study and their right to decline to answer any question without any repercussions.

I read each question aloud to the teacher and gave them ample time to respond. The first question asked the teacher to mention some misconceptions they observed among students and to describe the strategies they employed to address them. The second question asked the teacher to discuss some myths about mathematics learning they had observed in students and the approaches they used to reduce their impact. The final question asked the teacher to reflect on their teaching experience and mention some factors they believe contribute to the development of these misconceptions and myths. Throughout the individual interviews, I maintained an open and conversational tone, allowing each participant to speak freely and share their perspectives. I asked follow-up questions to clarify teachers' responses before proceeding to the next question.

The interviews were conducted in a quiet and private setting in the school. This private setting encouraged participants to share in-depth accounts, offer real-life examples, and reflect

on their teaching experiences openly (Knodel, 1993; Kruger et al., 2019). This setting is particularly helpful for discussing sensitive topics, as participants are more likely to feel comfortable sharing their views without the presence of others (Kruger et al., 2019).

The interviews concluded with an invitation for participants to add any further reflections or insights they felt had not been addressed. This allowed them to share additional thoughts that emerged during the discussion. I expressed appreciation for their participation, emphasizing the significance of their perspectives in deepening the understanding of student misconceptions and myths in mathematics learning.

Focus Group Interview

I designed the focus group to facilitate in-depth discussions among teacher participants, using open-ended questions to encourage detailed and dynamic exchanges (Hollander, 2004). I used the same questions from the individual interviews for the focus group discussion. This setting allowed participants to build on each other's responses, leading to shared insights and deeper reflectionThe focus group interview lasted approximately 2 hours. I facilitated the focus group discussion to ensure a conducive environment for open dialogue.

At the start, I welcomed the participants and provided an overview of the study's objectives. Before beginning the focus group interview, I informed participants that the session would be audio recorded to ensure accurate documentation of their responses. I sought their permission and ensured they were aware of the recording before proceeding. Participants were encouraged to speak freely and respectfully, with the assurance that their insights were valuable to the study.

As the discussion progressed, I posed each question, allowing ample time for participants to respond. I actively listened, occasionally prompting participants to elaborate on their points or

clarify their statements. This interactive format enabled participants to build on each other's responses, leading to a deeper exploration of the topics (Hollander, 2004). Participants engaged in detailed and dynamic exchanges, sharing anecdotes, providing examples, and reflecting on their experiences. I ensured that all voices were heard, managing the discussion to prevent any single participant from dominating the conversation.

The focus group discussion concluded with an invitation for participants to share any additional thoughts or concerns that had not been addressed during the session. This conclusion allowed participants to express perspectives they felt were overlooked or offer insights they had reflected on during the discussion. I thanked the participants for their contributions and reiterated the importance of their insights to the study.

Data Analysis

This section discusses how the collected data from the observation, individual and focus group interviews were analysed. Deductive thematic analysis was employed, using three pre-determined themes to analyze the data (McLeod, 2024). The pre-determined themes used in the analysis were based on the research objectives and derived from the theoretical framework. Using pre-determined themes as the basis for analysis ensured a targeted interpretation of the data which is aligned with the theoretical foundations of the study (McLeod, 2024). I organized the themes by grouping related codes that emerged from the three datasets—individual interviews, focus group discussions, and classroom observations— under the predetermined themes. Below, I present each pre-determined theme.

Misconceptions About Learning Mathematics

This theme explores the various misconceptions that students have about learning mathematics, as perceived by the teacher participants. I identified teachers' views about

misconceptions through specific statements within the data, such as: *One misconception is that regardless of whatever variable or unit they see there, they feel like once it's addition, you are supposed to put things together (Teacher B, line 449-451).* I coded this as *misconception about variables*. I used similar codes across all three datasets to illustrate how misconceptions were perceived.

Myths About Mathematics Learning

This theme examines the myths that students hold about mathematics learning, as perceived by the teacher participants. Regarding myths, I analysed teachers' comments such as: *Some of them have the belief that mathematics is boring (Teacher A, line 11-13).* I coded this as *mathematics is boring*. This myth suggests that students' attitudes can be shaped by widespread cultural beliefs that portray mathematics as uninteresting. I identified this code and other similar codes in the individual interviews, focus group interviews and the classroom observation data.

Factors Contributing to Misconceptions and Myths

This theme reflects on the factors that contribute to the development of students' misconceptions and myths about mathematics learning, based on the views of the teacher participants. I analysed teachers' comments such as: *Sometimes it comes from us [the teachers]. The methodology that we use, sometimes we go to the classroom not prepared (Teacher A, line 53-54)*. I coded this as *instructional practices*. This points to how instructional factors, such as lack of preparation, may reinforce students' misconceptions and myths about mathematics learning. I linked similar codes found in the individual interviews, focus group interview and classroom observations to show how teachers believe their instructional approaches, student backgrounds, and environmental factors may contribute to misconceptions and myths.

In presenting the findings, I integrated the assigned codes within each theme, highlighting patterns across the interviews, focus group discussions, and classroom observations to show a comprehensive view of the teachers' perspectives about students' misconceptions and myths (See Appendix E for all the codes I assigned related to each of the pre-determined themes).

The Analysis Process

The analysis of the data involved the following steps or stages inspired by Braun and Clarke (2006): (1) data transcription; (2) data familiarization; (3) coding; and (4) data sythesis. Each of these steps is described below.

Data Transcription. The transcription process involved converting the audio recordings of the individual interviews and the focus group discussion into written text. Each interview was transcribed verbatim, capturing every word spoken by the participants to ensure an accurate representation of their responses. This approach allowed for the preservation of the nuances in participants' speech, including some sense of the pauses, emphases, and non-verbal cues that were noted during the interviews.

To maintain the integrity of the data, I carefully reviewed the transcriptions against the original audio recordings, making necessary corrections to ensure accuracy. This step was crucial in minimizing transcription errors and ensuring that the participants' perspectives were faithfully represented.

In addition to the interview transcriptions, I also organized and typed my observational notes. These notes were taken during the classroom observations and included detailed descriptions of the teachers instructional methods, how the students participants engaged in the lesson, and the overall learning enronment.

All transcriptions and observational notes were typed using a word processor, specifically Microsoft Word. This software facilitated the organization and formatting of the data, making it easier to manage and analyze.

By ensuring that all data were accurately transcribed and systematically organized, I was able to create a dataset for subsequent analysis. This transcription process was fundamental in supporting the validity and credibility of the research findings.

Data Familiarization. Data familiarization is an important step in the analysis process (Braun & Clarke, 2006), where I immersed myself in the transcripts and observational notes to develop an understanding of the data. This process involved two key steps. First, I carefully read the individual transcripts, focus group transcripts, and observational notes separately to understand each dataset. This initial reading allowed me to grasp the overall content and context of the data. Next, I used the Comments feature in Microsoft Word to annotate the text with my initial thoughts, questions, and reflections during the reading process. These annotations included observations about recurring themes, notable quotes, and potential connections to the pre-determined themes. This step helped me to engage with the data and provided a preliminary framework for subsequent coding and analysis.

By familiarizing myself with the data, I was able to build a comprehensive understanding that informed the subsequent stages of the research process. This thorough engagement was essential for ensuring the validity and depth of the analysis.

Coding. After familiarizing myself with the interview transcripts, focus group transcript, and observational notes, I engaged in a systematic process of coding to analyze the data.

The coding was conducted within the pre-determined themes using Microsoft Word. For each dataset, I utilized the highlight feature in Microsoft Word to color-code recurring words, phrases,

and key ideas. Different colors were assigned to different key ideas within each dataset. For example, one color was designated for words reflecting misconceptions, another for references to myths, and additional colors for other significant themes. This color-coding system enabled me to visually organize the data more effectively.

Data Synthesis. Data synthesis is an important phase in qualitative research, where meaning is drawn from the analyzed data in relation to the research questions and theoretical framework (Braun & Clarke, 2006). This stage involves making sense of the themes and patterns that emerged during data analysis and linking them to the broader context of the study.

At the beginning of this stage, I employed member checking by sharing summaries of the findings with teacher participants to confirm that my interpretations accurately reflected their perspectives. After receiving feedback from teacher participants, I reviewed it carefully and found no need to make any modifications.

Next, I synthesized the data by summarizing each theme's key points and identifying recurring ideas and concepts that aligned with the themes. This approach enabled me to understand what the data revealed about each theme while linking these insights to the objective of the study. I compared the findings with existing literature and the theoretical framework to see if they align or differ, discussing possible reasons for any similarities or differences. Comparing the findings with existing literature and the theoretical framework guiding this study, I found that the findings support and, in some cases, challenge the framework, providing opportunities to expand or refine existing theories. In addressing the research questions, I identified which themes provide more insights into specific questions and assessed dimensions of each question where fewer insights were gained, considering the reasons behind this.

Finally, I identified limitations in the data or analysis and discussed how these might affect the interpretation of the findings. I also discussed the significance of the findings in the context of the broader research area, explaining how they advance knowledge or practice in the field. I considered the practical implications of the findings, exploring how they can be applied in practice, policy, or further research.

Ethical Considerations

This section identifies an ethical concern regarding this study related to a potential conflict of interest. I recognize that my role as a provider of materials at Mickinet Systems may influence participants willingness to participate in the study or influence those who agreed to participate to give answers they think align with my beliefs or expectations. Upon contacting the participants initially, some of them associated the study with Mickinet Systems and expected the study to be an extension of my organization.

To mitigate this, I took steps to reduce any potential pressure on participants to take part in this study. For instance, I always emailed instead of calling participants directly to help reduce any pressure they might feel. Through emails, I explained the research activities to the participants to give them enough time to consider their participation. In this way, I believe that the participants in the research had sufficient information and time to make a thoughtful rather than impulsive decision because of the roles my organization plays in their teaching experiences. I presented the purpose, scope, and methodology of the study and emphasized its distinction from my role within Mickinet Systems. I maintained transparency throughout the research process to uphold the study's integrity and credibility. There was clear communication that the research is separate from my role as a provider of materials and that the study is part of my university's M.Ed. program.

Summary

This chapter outlined the qualitative case study design used to explore teachers' perspectives on Ghanaian basic school students' misconceptions and myths about mathematics learning. It detailed the research design and data collection methods employed in this study. A case study design as well as individual interviews, a focus group discussion, and classroom observations were employed in this study. The data was analyzed using deductive thematic analysis inspired by Braun and Clarke (2006), with interpretations guided by the theoretical framework. Ethical considerations, particularly regarding my role as an educational resource provider, were also addressed to ensure transparency and mitigate potential biases.

Chapter 4: Findings

In this chapter, I present the findings from the data collected through individual interviews, focus group discussions, and classroom observations. I used the approach given by Braun and Clarke (2006) for the data analysis. Each of the stages in this approach has been discussed in Chapter Three. During the coding and data synthesis stages of the analysis process, my focus was mainly on teachers' perceptions of students' misconceptions and myths and what teachers perceive as contributing factors. To present the case of the selected school, I organized the findings around three pre-determined themes based on the research objectives and theoretical framework. The themes are (a) misconceptions about learning mathematics, (b) myths about mathematics learning, and (c) factors contributing to misconceptions and myths. Below, I present each theme, accompanied by the findings from the dataset.

Misconceptions about Learning Mathematics

This theme consists of what teachers reported to be students' misunderstandings in applying foundational mathematical concepts accurately. Analysis of the individual and focus group data revealed that teachers perceive students have misconceptions about aspects of mathematics including mathematical operations, such as adding or subtracting unlike terms, different measurement units, and operations involving negative numbers. Below, I present the misconceptions teachers reported and support each with quotes from the data.

Adding or Subtracting Unlike Terms

This misconception shows students' misunderstanding when they attempt to add or subtract algebraic terms with different variables, leading to errors in simplifying expressions and solving equations. Two of the four teachers reported that students often ignore the differences between variables, focusing solely on the numerical coefficients and applying addition or

subtraction indiscriminately. The following quotes from the focus group interview highlights teachers' beliefs about this misconception.

> "*... once they see these symbols there, they disregard the variable in the question, whether it's the same variable or not." (Teacher B, 2024).*

> *"When you ask them to simplify expressions, all they see is the coefficients" (Teacher A, 2024).*

This misunderstanding of variables was reflected in the observation data. During an observation of Teacher B's lesson, two students exhibited confusion when writing expressions involving variables and numbers such as *N-2* and *2y+3*, despite this learning objective being in the curriculum for earlier grades. One student questioned, *"How can you subtract 2 from N?" (Student A, 2024).* Another student (Student C) also argued that *2y+3* should give an answer of 5.

Operations Involving Negative Numbers

This misconception shows students' misunderstanding in performing operations involving negative numbers. Only one of the four teachers reported that students had misunderstanding of operations involving negative numbers. The following quote from the focus group interview data highlights this.

> *"So most of them, when we give them 7- (-2), they'll come and give you 5" (Teacher B, 2024).*

Teacher B explained further that students have this misconception because they assume subtraction leads to a reduction in size or magnitude.

> *"Every time they see the subtraction sign you must get a small figure" (Teacher B, 2024).*

This misconception was also observed in the classroom during Teacher A's lesson when one student argued that subtraction should result in a smaller number. For example, in response to the teacher's question about whether subtracting *(-4)* from *9* would cause a decrease or increase in magnitude, one student argued "*You must get a small figure when you subtract*" *(Student B, 2024).*

Operations Involving Different Measurement Units

This misconception reflects students' misunderstanding of correctly interpreting and using different measurement units during mathematical operations. One of the four teachers mentioned that students often disregard units when adding or subtracting measurements such as lengths. The students treat centimetres (cm) and millimetres (mm) as if they were the same unit, adding or subtracting the values directly without converting one of them to match the other. The following quote from the individual interview data highlights this misunderstanding.

> "*They don't even take their time to look at the measurement units; once they see that they have seen 15 and 20, regardless of centimeter or millimeter, they add (Teacher B, 2024).*

This tendency to overlook units was highlighted during the observations, where students exhibited a misunderstanding when working with varying measurement units. For example one student (Student B) was asked to solve *20 cm + 30 mm* on the board in front of the class. During my observation, I noted the student's written solution as 50. The student did not consider the measurement units and considered them 20 + 30, hence providing 50 as the solution.

Summary of Findings on Teachers' Perspectives of Students' Misconceptions

Teachers' perspectives of students' misconceptions in mathematics varied. Two of the four teachers reported that students struggled with adding or subtracting unlike terms,

particularly overlooking the role of variables and focusing only on coefficients. Misconceptions involving operations with negative numbers and different measurement units were mentioned by only one teacher (Teacher B). While observation of Teacher B's lesson highlighted these issues in the classroom, it is not possible from this data set to determine how widespread each of these misconceptions may be. The fact that I observed only two of each teacher's lessons and that these lessons may not have involved mathematics concepts that emerged in other classrooms was also a limiting factor. Therefore, further investigation across a broader range of classrooms and topics would be needed to assess their prevalence and significance more accurately.

Myths About Mathematics Learning

This theme presents what teachers reported to be some myths students have about mathematics learning. Analysis of the individual interview and focus group discussion data revealed five myths teachers believe that Ghanaian students have about mathematics learning. These include (a) students' perception of mathematics as exclusive, (b) the myth of inherited mathematical competence, (c) the myth that mathematics is difficult and boring, (d) the myth that mathematics requires memorization, and (e) the myth that mathematics involves several steps to arrive at a single solution. Below, I present each of the myths and support them with quotes from the data.

Students' Perception of Mathematics as Exclusive

This myth consists of students' belief that mathematics is exclusive to a certain type of person. One of the four teachers reported that students believe mathematics is for the gifted and talented. The following quote from the individual interview highlights this myth.

> *"... like maths is for those who are sharp, those who can think fast" (Teacher C, 2024).*

Teacher C further explained that this notion discourages students from pursuing mathematics.

> "*Some of them see themselves as if they are below, so they don't need to learn maths*" *(Teacher C, 2024).*

Also, two of the four teachers claimed that students believe mathematics is a male-dominated subject and that only males can succeed in mathematics. The following quotes highlight this myth.

> *"...especially, the girls, also have that kind of thinking that maths is for the boys. The calculation is for the boys" (Teacher C, 2024).*
>
> *"...some were saying that how can a female teach mathematics. So they have that thinking that mathematics is for men. Women or girls are not yet into that domain*" (*Teacher D, 2024).*

The other two teachers, Teacher A and Teacher B, did not report this belief during their individual interviews. However, during the focus group discussion, they nodded in agreement when the topic was raised, indicating a level of recognition or acceptance of the issue even though they did not report it. This nonverbal response suggests a broader, shared awareness among the teachers of the gendered perceptions students may hold about mathematics.

Inherited Mathematical Competence

The myth of inherited mathematical competence consists of the belief that one's success or failure in mathematics is determined by the performance of family members in mathematics—if they failed, one is destined to fail; if they succeeded, one is expected to succeed. Two of the four teachers reported that some students often attributed their success in mathematics to the performance of their family members in mathematics. The following quotes from the individual interview data highlight this myth.

> *"They come from homes where some of their colleagues were not able to do well... they already have this notion at the back of their mind that my brother was unable to pass mathematics. So due to that mathematics is more or less like a difficult area or discipline"* (*Teacher B, 2024).*
>
> *"Some of them also think that some people are born with mathematics. So if my mother is good in mathematics, therefore I must also be good in maths" (Teacher A, 2024).*

Mathematics is Difficult and Boring

This myth highlights the belief among students that mathematics is a challenging and uninteresting subject. One of the four teachers reported that many students perceive mathematics as a boring subject.

> *"Some of them have it that mathematics is boring. Some of them see it that the activities involved are not all that encouraging" (Teacher A, 2024).*

Additionally, one of the four teachers claimed that students generally perceive mathematics to be a difficult subject.

> *"I will say that learners in general think that mathematics is a difficult subject" (Teacher D, 2024).*

Mathematics Requires Memorization

This myth reflects students' belief that mathematics is primarily about memorizing formulas. One of the four teachers claimed students hold the belief that mathematics depends primarily on memorizing formulas. The following quote from the focus group interview data supports this myth.

"...they have the idea that you have to memorize formulas. So you memorize formulas for you to be able to arrive at the answer" (Teacher A, 2024).

During the discussion, I did not get a sense of whether the other teachers agreed with this statement from Teacher A.

Mathematics Involves Several Steps to Arrive at a Single Solution

This myth reflects students' belief that solving mathematics problems involves several steps that always result in a single correct answer. One of the four teachers mentioned that students believe mathematics problems require several steps or procedures to arrive at a single solution. The quote from the individual interview below highlights this myth.

"They have in mind that the answer is one way…like whatever you do, there are so many procedures you have to go through to get one answer" (Teacher A, 2024).

Although only one teacher reported this belief, the observation data reinforced this view. Teachers employed procedural, step-by-step instruction in all six classroom observations when solving mathematics problems. Additionally, one student argued that their answer is the correct one during problem solving. The following quote from observation of Teacher B's lesson highlights this finding, as stated by Student M. *"2n+4 is the correct answer, 2(n+2) is not" (Student M, 2024).* Student M argued that *2n+4* is the correct answer and *2(n+2)* is not the correct answer, despite both being mathematically equivalent.

Summary of Findings on Teachers' Perspectives of Students' Myths about Mathematics Learning

Teachers perceived that some students hold various myths about mathematics learning. These included beliefs that mathematics is only for certain types of people, such as the gifted or males, and that success in mathematics is inherited from family members. Other myths identified

were that mathematics is difficult and boring, that it relies primarily on memorization of formulas, and that solving mathematics problems requires following several steps to arrive at a single correct answer. Some of these perceptions were also reflected in classroom observations, particularly the emphasis on procedural approaches to problem solving.

Factors Contributing to Misconceptions and Myths

This theme consists of what these teachers perceive as factors that may contribute to misconceptions and myths among students. Analysis of the dataset revealed three main factors that these teachers perceive as contributing to misconceptions and myths: (a) teacher factors, (b) socio-cultural and home factors, and (c) student factors. I present each of the main factors below.

Teacher Factors

This focuses on teachers' views on teacher-related factors, such as teaching methods and teacher attitudes, that may impact students' misconceptions and myths about mathematics learning. One of the four teachers reported that teachers presented information without interactive or activity-based learning, making mathematics appear abstract. The quote from the individual interview below supports this finding.

> "*…so you always do the lecture method… it's abstract… you don't even add up anything for them to touch and feel" (Teacher A, 2024).*

This view was further echoed by the same teacher during the focus group discussion.

> "*It's not activity-based… you write and then give exercise. The child is not involved in anything*" *(Teacher A, 2024).*

During the focus group discussion, the other three teachers nodded as this view was expressed, indicating that it was widely held among the participants even if not explicitly restated by others. Also, the observation data revealed a more consistent pattern across all six classroom

observations. In each of the classrooms observed, teachers employed traditional lecture methods. No manipulatives or visual aids were used, and students did not participate in any hands-on or activity-based learning.

Additionally, one of the four teachers reported that some teachers, especially those not trained to teach mathematics, may pass on their fear of mathematics to their students.

> "*Not all teachers are trained to teach math, but since he is the class teacher, he has to teach math. Some of them fear maths but the teacher is compelled to teach mathematics, and the student develops that fear (Teacher C, 2024).*

One of the four teachers added a gender stereotypical dimension, noting that some male teachers sometimes undermine their female colleagues' abilities in mathematics.

> "*They [male teachers] still think that we don't have the knowledge to teach math… and as a woman, you wouldn't feel like learning or trying to teach*" *(Teacher D, 2024).*

Teacher D also explained further that sometimes male teachers look down on their female colleagues unintentionally in the presence of the children, and therefore, could impact students' confidence in the female mathematics teacher. The quotes from the individual interview data below highlight the teacher-related gender stereotype.

> *"If we go for math workshops, you are going to see a lot of males over there. The moment they see females they are like mmm, what can she do" (Teacher D, 2024).*
>
> *"They [male teachers] might be having a conversation with the learners and mistakenly, not that they wanted to do it but indirectly they would belittle the female math teachers without even knowing that they have even done that" (Teacher D, 2024).*

While the other teachers did not echo this view, I believe it presents an important dimension of the broader socio-cultural factors that may contribute to gendered perceptions in mathematics learning environments. Notably, Teacher D, the only female teacher in this case study, also had about 10 years less teaching experience than the other three teachers. As a newer teacher, her views may differ somewhat from others.

Socio-cultural and Home Factors

This examines these teachers' views on how students' socio-cultural backgrounds might influence their misconceptions and myths. Three of the four teachers shared views that highlighted the influence of home dynamics and cultural attitudes on students' perceptions about mathematics learning. One of the four teachers (Teacher A) pointed out that the confidence level of parents may limit students' participation in mathematics at home. In households where one parent is perceived as less competent in mathematics, children may avoid engaging with the subject in the absence of the other parent. Teacher A illustrated this with a personal example:

> *"My wife is not good in mathematics…So when my child comes home with mathematics activities, he has to close the book and wait for me when I'm not around. So they don't do math" (Teacher A, 2024).*

Additionally, two of the four teachers (Teachers B and C) reported that students often arrive at school with preconceived notions about mathematics, shaped by comments or experiences within the home. Teacher B explained that past negative experiences of family members can instill fear in students about mathematics.

> *"Those who previously passed through the system [schooling] have put some fear in others in their family about mathematics. So they come to the class with that fear" (Teacher B, 2024).*

Teacher C also emphasized the cultural perceptions about the usefulness of mathematics.

> *"They [family members of students] thought that maths is not needed as such. Especially some of the topics. What are they going to use it for. Let's say the X = 2, what is the X for? What are they going to use that thing for in life? So students also question its relevance" (Teacher C, 2024).*

These accounts suggest that students' engagement in mathematics is not only formed within the classroom but is also shaped by the beliefs and mathematical experiences within their families and communities. While not all teachers raised this issue, the data points to the need for schools to consider home-school dynamics and involve parents in ways that promote positive attitudes toward mathematics.

Student Factors

This examines teachers' views of student-related factors, such as attitudes and learning habits, in shaping their misconceptions and myths about mathematics learning. Teachers mentioned that students' beliefs about their own abilities and their learning habits can significantly impact their understanding and engagement with mathematics. Two of the four teachers reported student-related factors that may contribute to misconceptions and myths. Teacher B mentioned that students' lack of confidence in their mathematical abilities often stems from fear, which is influenced by negative family experiences with mathematics, which students internalize.

> *"My sister has been writing mathematics [exam] for the past five years now without passing… it means this mathematics is very difficult. So this fear gets into the students, and they develop anxiety about mathematics and therefore do not want to pursue it." (Teacher B, 2024)*

Additionally, Teacher A noted that students fail to put in the effort required to build their skills in mathematics, viewing it as a subject that does not require regular engagement.

> *"Mathematics needs constant practice… the child does not, is not involved in anything and does not practise solving mathematics problems" (Teacher A, 2024).*

A notable finding revealed by the observation data is the low level of student engagement during mathematics lessons. In all six classroom observations, students were passive receivers of information. The students did not interact with manipulatives or engage in mathematics tasks. Even though there was some interaction amongst students, their overall engagement and involvement in the lesson was passive.

Summary of Findings on Teachers' Perceptions of Factors Contributing to Misconceptions and Myths

The teachers in this case study perceived that several factors contribute to students' misconceptions and myths about mathematics learning. Teacher-related factors included the use of lecture-based methods without hands-on activities, teacher discomfort toward mathematics, and gender stereotypes that undermine female mathematics teachers. Socio-cultural and home factors were also highlighted. These included family members' attitudes toward mathematics, including fear, lack of confidence, and questioning the subject's relevance. Student-related factors included low self-confidence, discomfort in mathematics influenced by family experiences, and poor learning habits, such as a lack of regular practice. Classroom observations also reflected low levels of student engagement, with teaching largely lecture-based and students being passive during learning.

Summary

In this chapter, I presented findings from the collected data using three pre-determined themes derived from the theoretical framework. Although I identified six student participants in each classroom—two from each achievement level with assent/consent—my classroom observations did not yield extensive data focused on these individuals. While I intended to observe their interactions, engagement, and the presence of miscinceptions and myths, most students—including the selected students—remained relatively passive during lessons. This limited interaction likely stemmed from the direct instructional approaches used by teachers in my study, which did not encourage peer collaboration. As a result, I was unable to gather rich interactional data from these students to fully complement findings from interviews and focus groups.

A detailed discussion of the findings is presented in the next chapter, drawing on the literature reviewed in Chapter Two and other relevant studies. This discussion contextualizes the findings within existing research, providing insights and potential implications for addressing these challenges in mathematics education.

Chapter 5: Discussion and Closing Thoughts

This chapter explores the findings from Chapter Four, addressing two key research questions about teachers' perspectives about misconceptions and myths in mathematics among Ghanaian students and the factors teachers believe contribute to these issues. I begin with a summary of the study, including the problem statement, significance, literature review, methodology, and methods. I then highlight how the findings provide insights into the research questions and explore potential reasons behind these findings. Next, I compare the study's findings with existing literature, noting alignments and contradictions. Finally, I conclude by discussing the study's contributions, limitations, and future research directions.

Summary of the Study

This study investigated teachers' perspectives about misconceptions and myths about mathematics among Ghanaian basic school students and the factors that teachers believe contribute to these issues. Research shows that misconceptions can hinder learning and foster negative attitudes (Hiebert & Grouws, 2007). While globally documented (Acharya, 2017; Stothard, 2021; Jankvist & Niss, 2018), their specific nature in Ghana is less understood. This study aimed to fill this gap.

Theoretical foundations from Piaget (1977) and Vygotsky's (1978) notions of constructivism informed the research, with the ITSE model guiding data collection. Using a qualitative case study design, I gathered data through teacher interviews, individual and focus group, and classroom observations. I employed data analysis processes inspired by Braun and Clarke's (2006). Three pre-determined themes were derived based on the research objectives and theoretical framework and used for the analysis.

Summary of Key Findings

The key findings of this study are outlined below.

1. Teachers' Perspectives of Student Misconceptions:
    - *Adding or Subtracting Unlike Terms*: Students show a misunderstanding in adding or subtracting algebraic terms with different variables
    - *Negative Numbers*: Students show a misunderstanding of operations involving negative numbers.
    - *Symbols and Measurement Units*: Students overlook symbols or units in expressions.
2. Teachers' Perspectives of Student Myths:
    - Perception of mathematics as an exclusive subject, accessible only to men, the intellectually gifted, and those from mathematically inclined families.
    - Mathematics is procedural to obtain a single answer and requires memorization
3. Factors Contributing to Students' Misconceptions and Myths:
    - Teachers' instructional practices include using traditional, lecture-based instructional methods, focusing on rote memorization and procedural learning rather than fostering conceptual understanding.
    - Teachers' discomfort with mathematics could unintentionally influence students' attitudes, potentially discouraging engagement or reinforcing negative beliefs.
    - Students' socio-cultural backgrounds

Discussion of the Findings

In this section, I discuss the study's findings in relation to the literature, organized around the two research questions. Each question is presented with corresponding findings, highlighting agreements or disagreements with previous research and comparing methods and contexts.

Research Question 1: What Are Teachers' Perspectives on the Misconceptions and Myths That Basic School Students in Ghana Exhibit in Their Mathematics Learning?

Misconceptions about Unlike Variables or Terms. One finding of this study was teachers' perspectives of students' tendency to incorrectly simplify expressions with unlike variables or terms. For example, when presented with $2y+3$, some students disregarded the variable and added only the numerical coefficients, arriving at 5 as the answer. Similarly, expressions such as $N-2$ often left students questioning the feasibility of subtracting a number from a variable. This finding aligns with the dual nature of algebraic expressions as both processes and objects (Dreyfus et al., 1990). As such, students struggle to differentiate when to treat an expression as a process or as an object. In the given example, $2y+3$, some students considered the expression as a process that needed to be evaluated and therefore ignored the variable. According to Dreyfus et al. (1990), this complexity could lead students to perceive expressions as incomplete, prompting oversimplification and the adoption of incorrect methods.

The implications of this misconception are profound. The tendency to disregard variables suggests a lack of understanding of algebraic notation and its role in representing relationships. Without a strong grasp of these foundational concepts, students may struggle to develop the higher-order thinking skills needed for advanced mathematics (Egodawatte, 2011). That is, this misconception can impact students' ability to understand more complex algebraic concepts, ultimately affecting their performance in higher-level mathematics. Egodawatte (2011) noted that

this lack of structural understanding often leads to errors during mathematics problem-solving activities.

This finding also aligns with Moss et al. (2018) and Obot (2023), who observed that students frequently ignore variables when solving expressions. Obot (2023) explained that this issue may stem from students' familiarity with real-life contexts where letters are used to represent concrete quantities—such as letter A for area or letter T for time. Students may consider variables as specific objects or words rather than abstract symbols that can take on a range of numerical values.

From a constructivist standpoint, this finding informs teaching practices by emphasizing the need for instructional strategies that help students integrate new algebraic concepts into their existing mental frameworks (Piaget, 1977). According to Piaget's theory of assimilation, when students encounter new knowledge, they attempt to integrate it into their pre-existing understanding (Piaget, 1977). In the case of algebra, this could involve students connecting the abstract concepts of variables and terms to their prior experiences with numbers and operations. Contextualized problems that bridge real-world applications with abstract algebraic concepts also support the assimilation process. These problems give students opportunities to relate new information to their own experiences, thereby strengthening their understanding (Davis, 2016). By linking new algebraic ideas to practical scenarios, students are encouraged to adapt their understanding, allowing them to see the relevance of algebra in everyday life. Additionally, using manipulatives or visual aids can help represent algebraic expressions as cohesive, dynamic entities, allowing students to see the relationship between numerical and variable components more clearly (Boaler, 2016).

Misconceptions About Operations With Different Measurement Units. Another misconception closely related to the unlike variable misconception was students' incorrect treatment of unlike measurement units. For instance, students solved *20 cm + 30 mm* as *50*, ignoring the difference in units and treating them as though they were the same units. This reflects a difficulty in recognizing and respecting distinctions between measurement units. A plausible reason for this misconception is students' tendency to ignore variables or letters discussed in the previous section. The misconception of ignoring variables was reflected in this finding, as students ignored the measurement units and added the numbers attached to the units.

Additionally, this finding aligns with the challenges identified by Olive and Çağlayan (2008), who explored students' struggles with coordinating quantitative units in algebraic word problems. Their study emphasizes that effective problem-solving in mathematics, especially in algebra, requires the ability to identify, differentiate, and coordinate multiple levels of units. The findings in this study revealed that some students did not recognize the identity and relationships of the units involved, operating as if both measurements were the same unit. This challenge indicates a need for instructional strategies that go beyond procedural teaching and instead cultivate deeper conceptual understanding of how units of measurement function and interact in mathematical expressions (Olive and Çağlayan, 2008). Like the misconception about unlike variables, using visual aids and manipulatives can help students relate concrete concepts to abstract concepts (Uribe-Flórez & Wilkins, 2010).

Misconceptions with Negative Numbers. The study also revealed teachers' views of students' misconceptions with operations involving negative numbers. Specifically, students viewed subtraction as an operation that results in a reduction in size or magnitude. Hayes and Stacey (1998) similarly observed that students find it difficult to conceptualize subtracting larger

numbers from smaller ones or combining negative values, partly due to deeply ingrained beliefs that subtraction always signifies a reduction in size. This misconception points to the need to more deeply explore the concept of subtraction. It also highlights the need for targeted instructional approaches that clarify the concept of negative values and provide students with opportunities to practice operations with both positive and negative numbers. One such approach is contextual learning (Bruno & Martinon, 1999). Contextual learning involves introducing negative numbers through real-life contexts that make the learning relevant and relatable. For instance, teachers can use distance below sea level, overdrawn accounts or debts and temperature below freezing to help students make negative numbers more concrete for their students. Addressing these misconceptions can support students in developing a more accurate understanding of numerical operations, which is essential for their progression in learning basic mathematics concepts (Bruno & Martinon, 1999).

These findings emphasize the need for teaching interventions that strengthen students' conceptual understanding of variables, measurement units, and operations with negative numbers. Addressing these misconceptions requires teachers to emphasize the structural nature of algebraic expressions and the contextual meaning of variables and symbols (Bruno & Martinon, 1999). Moreover, providing students with opportunities to practice negative number operations and measurements could support their progression in mastering foundational mathematical concepts.

Regarding teachers' views of myths about mathematics learning held by students, this study found the following myths: (a) mathematics is procedural and requires memorization to obtain a single answer, and (b) mathematics as an exclusive subject. Each of these myths are discussed below.

Memorization, Procedural Focus and the Single Answer Belief. A notable myth described by one of the four teachers was the students' perception of mathematics as a system of rigid procedures designed to yield a single correct answer. The same teacher also described that students believe mathematics requires memorization of formulas and steps. These findings align with the literature on the overemphasis on procedural knowledge over conceptual understanding (Jankvist & Niss, 2018; Rittle-Johnson & Schneider, 2015; Van de Walle et al., 2013). According to Rittle-Johnson and Schneider (2015), many students tend to memorize steps without understanding the underlying ideas. This reinforces the wrong notion that there is only one correct path to solve a problem and one solution to a problem. Such beliefs could impact students' ability to link new concepts to prior knowledge (Jankvist & Niss, 2018; Van de Walle et al., 2013). Addressing these beliefs requires shifting instructional focus toward conceptual understanding—as emphasized in the literature—to help students develop a deep, more flexible mathematical reasoning (Rittle-Johnson & Schneider, 2015) From a constructive perspective, the types of mathematical tasks teachers choose can impact students' understanding of mathematics concepts (Stein et al., 2009). As Stein et al. (2009) emphasize, tasks must require meaningful engagement and promote connections between real-world experiences and mathematical principles.

Mathematics as an Exclusive Subject. The participating teachers reported that students held the belief that only those who are gifted and intelligent can excel in mathematics. This finding aligns with previous research by Chestnut et al. (2018) and Franz et al. (2016), which revealed that societal attitudes often cast mathematics as a discipline requiring a rare level of intellectual ability, thus deterring students who do not see themselves as naturally gifted. The belief that only the gifted and intelligent can succeed in mathematics contributes to a fixed

mindset, where students may feel discouraged from pursuing mathematics if they do not identify as *math people* (Franz et al., 2016). Chestnut et al. (2018) noted that this fixed mindset is problematic because it can limit students' willingness to engage in mathematics. To dispel this perception, I believe that teachers should place more emphasis on effort, persistence, and learning strategies over innate ability. Teachers can help foster a growth mindset by highlighting that mathematical skills are developed through practice and resilience, not talent.

The study also uncovered gender stereotypes reinforcing the perception of mathematics as an exclusive field, often seen as a male domain. One of the teachers, the only female teacher in the study, reported that many students, particularly girls, believe that mathematics is suited for boys, with male students seen as naturally more capable in the subject. The teacher also added that male colleagues sometimes unintentionally undermine their female colleagues' abilities in mathematics. This finding aligns with studies that highlight the pervasive myth linking mathematical ability to gender (Chestnut et al., 2018; Fennema et al., 1990; Leyva, 2017; Sheffield, 2017). Sheffield (2017) noted that stereotypes often portray males as naturally more capable in mathematics, while females are viewed as less suited for the subject. When girls internalize the belief that mathematics is a male-dominated field, they may be less inclined to pursue it, thereby perpetuating gender disparities in mathematics fields (Fennema et al., 1990). Research shows that these beliefs often stem from societal norms (Fennema et al., 1990; Leyva, 2017; Sheffield, 2017). Such biases may contribute to unequal treatment and opportunities for female students in mathematics classrooms. Leyva (2017) challenged these stereotypes and argued that they lack an empirical basis. Chestnut et al. (2018) noted that these stereotypes can discourage female students from engaging with mathematics.

In drawing on the theoretical framework presented in Chapter Two, which extends the learning environment beyond the classroom, I posit that the myths reported by teachers in this Ghanaian context are deeply intertwined with broader socio-cultural narratives. These myths—such as the belief that mathematics is only for the gifted or male students—are not confined to the classroom but reflect societal views that influence students' engagement with mathematics. It is particularly striking that these myths closely mirror those documented in the broader international literature. This suggests that these views are not isolated or unique to one cultural or educational setting but may be part of a widespread societal narrative about mathematics and who is capable of learning it. The alignment between the views reported by the teachers in this study and global research (e.g., Chestnut et al., 2018; Franz et al., 2016; Fennema et al., 1990; Leyva, 2017) highlights the pervasive nature of fixed mindsets and gendered beliefs in mathematics education. This emphasizes the importance of addressing these myths not only through local interventions but also by situating such efforts within a broader international conversation about equity, mindset, and access in mathematics learning. This conversation should bring together educators, researchers, and policymakers from around the world to challenge the deeply ingrained beliefs about gendered stereotypes in mathematics learning. By addressing these myths on an international scale, a collective effort can be made to redefine the narrative around who is capable of learning and excelling in mathematics. This global dialogue is important in promoting equity and ensuring that all students, regardless of gender, background, or ability, have the opportunity to engage with and succeed in mathematics education.

Research Question 2: What do teachers perceive as factors contributing to the development and persistence of these misconceptions and myths?

This research question sought to explore teachers' views on the factors that may contribute to the development and persistence of misconceptions and myths about mathematics learning among basic school students in Ghana. Teachers play an important role in shaping students' attitudes and beliefs about mathematics, and their insights provide valuable context for understanding the social, cultural, and instructional elements that may influence students' misconceptions (Yilmaz et al., 2010).

Teachers in this study reported a number of factors that may contribute to misconceptions and myths. I have grouped these factors into three main factors: (a) teacher-related factors, (b) student-related factors, and (c) socio-cultural and home factors. Each of these factors is discussed below.

Teacher-Related Factors. The perspectives of participating teachers in this study indicated that teacher-related factors such as teachers' instructional practices played a role in shaping students' misconceptions and myths about mathematics learning. One teacher (Teacher A) reported that learners are mostly passive during mathematics lessons because teachers do not facilitate the lesson. The constructivist learning theory (Charles, 2020; Quintero & Rosario, 2016) discussed in Chapter Two emphasizes the importance of teachers as catalysts for meaningful engagement in mathematics learning, advocating for instructional methods that promote active learning. Teacher facilitation involves more than simply delivering content; it requires creating opportunities for students to actively construct their own understanding through rich, cognitively demanding tasks (Stein et al., 2009). When teachers primarily use direct instruction without facilitating exploration and student-centered learning, it mirrors the pattern of

low cognitive demand tasks that limit students' conceptual development (Stein et al., 2009). The study's finding that students are often passive during lessons highlights a lack of effective teacher facilitation, reinforcing what the literature suggests—that without purposeful facilitation, students may view mathematics as a set of rigid rules rather than a field open to reasoning and exploration

Another teacher-related factor that emerged from the study was teacher discomfort in mathematics. One teacher (Teacher C) reported that, in many cases, class teachers who lack formal training in mathematics are still required to teach it, which can result in the transfer of their own fear of the subject to their students. This finding aligns with Ramirez et al. (2018), who found that teachers' discomfort in mathematics correlates with lower student achievement in mathematics. Ramirez et al. (2018) further identified that teachers with mathematics discomfort tend to adopt ability-oriented teaching methods, which may reinforce students' perceptions of mathematics as an exclusive subject. These findings emphasize the importance of equipping teachers with both content and pedagogical knowledge for effective teaching and learning (Thames & Ball, 2010). Professional development programs should focus on integrating teachers' knowledge in mathematics content and pedagogy (Thames & Ball, 2010).

Thames and Ball (2010) emphasize that strong mathematical knowledge for teaching (MKT) including mathematics content knowledge enables teachers to recognize the underlying structures of problems, anticipate student misconceptions, and present concepts in multiple ways to support diverse learners. Equally important in MKT is pedagogical knowledge—understanding how students learn mathematics and how to design instruction that fosters conceptual thinking rather than rote memorization (Thames & Ball, 2010). By integrating these two dimensions, professional development can better equip teachers to create learning

environments where students actively engage with mathematical ideas, make meaningful connections, and develop flexible problem-solving skills (Thames & Ball, 2010).

Student-Related Factors. The study found that teachers believe that student-related factors, such as individual attitudes and levels of discomfort in mathematics, are factors that can contribute to misconceptions and myths about mathematics learning. Two teachers reported that many students expressed lack of confidence in mathematics, which hindered their engagement and made it difficult for them to grasp concepts effectively. These negative experiences, often rooted in societal beliefs that portray mathematics as a challenging subject, have the tendency to impact students' learning of mathematics (Ramirez et al., 2018). Ramirez et al. (2018) found that students' attitudes and anxieties directly impact their performance in mathematics. While this study focused on teachers' perspectives rather than an empirical direct relation between student discomfort and performance, the findings of Ramirez et al. (2018) nonetheless reinforce the concerns expressed by teachers in this study. Students who experience high levels of discomfort in mathematics may not actively engage with mathematics, reinforcing misconceptions and reducing overall achievement (Ramirez et al., 2018).

Teachers also repoted students' perception of mathematics as difficult and boring. This perception could be influenced by a lack of connection between new concepts and their prior knowledge. Chen et al. (2018) noted that students may develop this perception of mathematics as difficult and boring when teachers do not integrate new ideas with students' prior learning. Without these connections to prior knowledge, students may struggle to see the relevance of new concepts, leading to frustration and disengagement. Therefore, making clear connections between new concepts and students' previous understanding is important to reducing the perception of mathematics as a difficult and uninteresting subject.

Socio-Cultural and Home Factors. The study also found that three of the four participating teachers believed that students' socio-cultural backgrounds contribute to their misconceptions and myths about mathematics learning. As discussed in relation to research question one, teachers felt that students frequently enter the classroom with preconceived beliefs that mathematics is difficult, exclusive, or only for individuals with the inherent gift. The teachers thought that these beliefs often stem from family and community influences, where students may have heard that mathematics is only for certain people or that only specific individuals can excel in mathematics. Such statements contribute to a fixed mindset, which can prevent students from engaging with mathematics confidently (Chestnut et al., 2018).

This finding is consistent with research by Crane (2001) and Pangeni (2014), which highlight a strong relationship between parental background and student performance. Their studies indicate that families with supportive attitudes and higher levels of education are more likely to cultivate an interest in mathematics among their children. This highlights the importance of family involvement and awareness in the learning process of students. Schools and teachers can play a role in engaging parents and educating them about the importance of mathematics, offering resources or workshops to help parents support their children's learning at home. Given the socio-economic background of the school—the case of the study—where the head teacher explained that many families engage in small-scale trading and face significant economic pressures, active family involvement in supporting mathematics learning may not always be feasible without deliberate efforts from the school. Therefore, this finding highlights the need for schools to create opportunities to engage parents, recognizing the economic realities they face. In a community where daily survival may take precedence over educational involvement, schools must take a proactive role in fostering parents' awareness of the

importance of mathematics education and equipping them to support their children's learning despite socio-economic challenges (Ghana Education Service, 2024).

Implications of the Findings

The findings of this study, grounded in teachers' perspectives, offer important implications for teachers, students, and the learning environment in Ghanaian middle-school contexts and beyond. Since the study focused on how teachers perceive the development of student misconceptions and myths, the implications highlight the need to rethink teacher practices, beliefs, and systemic supports available to teachers in Ghana. I present the implications in three main areas: (1) professional development, (2) curriculum enhancements, and (3) insights for provision of education materials

Professional Development

Teachers' identification of student misconceptions—such as misunderstandings in adding unlike terms, operations with negative numbers, and interpreting symbols and units—points to the need for strengthening teachers' focus on developing students' conceptual understanding. From the teachers' perspective, improving student learning will require moving beyond procedural instruction towards deeper, meaning-centred mathematics teaching (Rittle-Johnson & Schneider, 2015). Professional development programs should therefore prioritize building teachers' capacity to create tasks that help students make meaning out of mathematical concepts by connecting mathematical ideas to real-life situations, rather than relying on rote memorization (Chen et al., 2018). This emphasis aligns with the Ghanaian basic school mathematics curriculum standards, which advocate for mathematics instruction that enables learners to understand and explain the world around them, predict and analyze phenomena, and become mathematically literate citizens (Ministry of Education, 2020).

The curriculum further highlights the importance of hands-on teaching approaches to help learners find mathematics engaging and relevant to their daily lives. These goals reinforce the importance of conceptual instruction and suggest that efforts to address student misconceptions should be grounded in the curriculum's vision of meaningful and active mathematics learning. The findings in my study highlight the need for professional development that prepares teachers to adapt their instructional strategies to meet the goals of the Ghanaian standards-based curriculum. Notably, professional development efforts to support teachers in these practices must be tuned to the realities of the classrooms where they teach which may have as many as 100 students in them and may have limited access to mathematics teaching materials such as manipulatives. Strategies that might make it more possible for teachers to gain a sense of students' prior knowledge or current understanding of a concept, while working with a large class would be helpful.

Curriculum Enhancements

The findings also point to opportunities for improving the Ghanaian mathematics curriculum by making common student misconceptions and harmful learning myths more visible in the curriculum document itself. Many international curricula include guidance on disrupting negative student beliefs and stereotypes about mathematics learning; a similar section could be added to Ghana's curriculum to equip teachers with strategies for promoting more inclusive and positive classroom discourse. Additionally, the curriculum could be enriched by embedding specific misconceptions within content descriptions. For instance, in the section on measurement, it could highlight common misunderstandings—such as attempting to add or subtract quantities expressed in different units (e.g., adding 5 cm to 2 m without converting units)—and provide guidance for addressing these misconceptions through classroom tasks and

explanations. Including such examples would serve both as a teaching guide and as a tool for professional learning, helping teachers anticipate and respond to student difficulties more effectively.

Insights for Provision of Educational Materials

As a provider of educational materials, the findings from this study offer important implications for the development and distribution of teaching and learning resources. To address the misconceptions and myths identified by teachers, materials should be purposefully designed to promote conceptual understanding rather than rote memorization. This can be achieved by incorporating culturally relevant and real-world examples that connect with students' lived experiences, making mathematical ideas more meaningful and accessible. In resource-limited settings, where classrooms may lack sufficient teaching aids, the use of low-cost or locally sourced visual aids and manipulatives could be helpful. Such materials can support hands-on, activity-based learning and help bridge the gap between abstract concepts and practical understanding. By aligning the design of educational materials with the contextual realities of Ghanaian classrooms, resource developers can play an important role in supporting meaningful mathematics learning and actively challenging misconceptions and myths that hinder student progress.

Limitations of the Study

While this study offers valuable insights into teachers' views of misconceptions and myths in mathematics learning among Ghanaian basic school students, I acknowledge several limitations of the chosen methodology and data collection.

Firstly, some participating teachers felt uncomfortable sharing experiences regarding gender stereotypes during the focus group interviews. Although they shared these experiences in

individual interviews, I found that their discomfort seemed to lead to guarded responses in the group setting. Moreover, a single individual interview each teacher and only one focus group discussion with a teacher may not have been sufficient to fully capture the breadth and depth of all of their perspectives on myths and misconceptions in mathematics learning.

Secondly, with only two observation sessions—each lasting one hour—conducted for each of the Grade 7, 8, and 9 classes, the study offered a limited view of the range of mathematics content and student interactions across different topics. As a result, misconceptions that may be prevalent in other areas of the curriculum were not captured. Additionally, challenges such as classroom noise, overcrowded classrooms, and seating arrangements made it difficult for me to clearly hear all student discussions, limiting the ability to fully access their thinking processes. It is also possible that mathematics teaching unfolded in a more interactive manner during some class meetings than in the ones that I observed though the comments of the teachers about mathematics pedagogy suggest that this was not the case.

Thirdly, the time constraints of the focus group interview restricted the opportunity for every participant to fully express their thoughts and experiences, resulting in some valuable perspectives being overlooked or underrepresented.

Finally, potential biases in data collection and analysis must be acknowledged. My dual role as a mathematics teacher and provider of resources for teachers might have influenced teachers' responses and students' behavior. Despite efforts to maintain a non-judgmental stance, participants may have perceived me as an authority figure, impacting the authenticity of their responses. Additionally, my own experiences and expectations shaped the coding process, potentially leading to an overemphasis on themes aligned with my prior knowledge or theoretical orientation while also giving me valuable insights into this case study.

Despite these limitations, I ensured that the data collection and analysis processes were conducted as systematically as possible. I explicitly clarified my role as a researcher, distinct from my role as a provider of resources. Participants were reassured that the study's purpose was solely to gather insights, not to evaluate their teaching practices or personal opinions. By acknowledging these limitations, the findings can be interpreted within the study's scope and offer valuable contributions to understanding misconceptions and myths in mathematics learning among Ghanaian basic school students.

Closing Thoughts

This study examined teachers' perspectives of the misconceptions and myths that Ghanaian basic school students hold about mathematics learning, alongside teachers' perspectives on the factors contributing to these misconceptions and myths. Employing a qualitative case study approach, data were gathered through teacher interviews and classroom observations.

The findings provided insights into participating teachers' perspectives of students' misconceptions and myths in mathematics learning. They reveal that teachers believe instructional practices, teacher discomfort, and socio-cultural factors could contribute to students' misconceptions and myths about mathematics learning. While these perspectives are shaped by the Ghanaian context, they resonate with findings from international studies that also link misconceptions and myths in mathematics to teaching approaches, societal attitudes, and learner confidence. However, notable differences in contexts, such as overcrowded classrooms and limited teaching and learning resources, underscore the uniqueness of this study. These systemic challenges may not be as pronounced in other settings. By understanding these dynamics, educators can better address the root causes of these misconceptions and myths,

ultimately enhancing the effectiveness of mathematics education in Ghana. This study not only highlights the challenges but also provides a pathway for developing more informed and responsive teaching strategies. In the next sections, I present my reflections—first, on how my thinking about misconceptions and myths evolved after the study, and second, on insights gained through engagement with Charles' constructivist model, which I adapted for this study.

Evolution of My Thinking on Misconceptions and Myths

After the study, my understanding of misconceptions and myths evolved significantly. I initially defined misconceptions as misunderstandings of mathematical concepts and myths as false beliefs about mathematics learning. I viewed both as negative barriers that needed to be corrected. However, reflecting on teacher narratives and classroom realities after the study, I now see misconceptions and myths as productive starting points for learning. Even when flawed, partial, or negative, these ideas represent prior knowledge that can be built upon rather than dismissed. I believe they offer valuable foundations from which meaningful learning can develop.

Reflections on Charles' Constructivist Model

During the study, I reflected more deeply on Charles' (2020) constructivist model, which emphasizes the interconnection among teacher practices, student engagement, and the learning environment. Engaging with the data in light of this framework made me reflect on how these elements are experienced in the classroom and how they may relate to the development of misconceptions and myths. For instance, I wonder how a classroom where the teacher uses predominantly lecture-based instruction and limited student interaction might reinforce myths such as *mathematics is only for the gifted*, whereas a classroom that fosters active participation with culturally relevant examples and hands-on activities could help challenge these myths.

Future research might build on this by examining how different educational environments reinforce or challenge the relationships proposed in Charles' constructivist model. Comparative studies across varied settings or longitudinal investigations could contribute to further development of the model by providing insight into how the interplay of teacher, student, and environment evolves over time and in different circumstances. This reflection leads directly into the next section, where I outline possible directions for future research to extend these insights.

Other Future Directions for Research

Future research could expand on these findings by addressing specific areas that delve deeper into the misconceptions and myths about mathematics learning. One area worth investigating is the the influence of gender stereotypes on students' attitudes and performance in mathematics in Ghana. I observed that some teachers felt uncomfortable when discussing gender-related stereotypes in mathematics teaching and learning, and future research could examine how these stereotypes may relate to student engagement and experiences in mathematics teaching and learning.

Further research could also consider the role of teacher professional development in addressing misconceptions and myths. Studies might investigate how training focused on constructivist and inquiry-based approaches supports teachers in identifying and responding to students' misconceptions and myths. There may also be value in examining how these instructional approaches align with the aims of Ghana's Standards-Based Curriculum, particularly in helping students connect mathematical ideas to real-life situations.

Additionally, future studies could explore the intersection of cultural beliefs and mathematics learning, investigating how deeply ingrained societal myths, such as the notion that

mathematics is inherently difficult or reserved for specific gifted individuals, affect students' motivation and perceptions of the subject.

Since I explored teachers' views about students' misconceptions and myths using the case study approach, it might be argued that these findings are solely valid for this specific group of students. However, it may be more productive to consider how this case study approach could be further developed to gain deeper insights. For instance, future studies could involve multiple schools across varied regions, incorporate longitudinal observations, or include student interviews to triangulate perspectives. Such expansions would enrich our understanding of how misconceptions and myths emerge and persist across diverse educational settings in Ghana.

My journey as a researcher will not end with this study. I plan to explore and test effective interventions to address the misconceptions and myths about mathematics learning identified in this research. By testing and evaluating these interventions, I aim to develop practical strategies that can potentially improve students' perception of mathematics and support their learning in a more meaningful way. This next phase will be crucial in translating my findings into actionable solutions that can positively impact the teaching and learning of mathematics in Ghanaian schools.

References

Acar, E., & Yılmaz, A. (2015). Building a constructivist social learning environment through talk in the mathematics classroom. *International Journal of Human Sciences*, *12*(1), 991. https://doi.org/10.14687/ijhs.v12i1.3123

Adeoye-Olatunde, O. A., & Olenik, N. L. (2021). Research and scholarly methods: Semi-structured interviews. *JACCP: Journal of the American College of Clinical Pharmacy*, *4*(10), 1358–1367. https://doi.org/10.1002/jac5.1441

Aliustaoğlu, F., Tuna, A., & Biber, A. (2018). The misconceptions of sixth grade secondary school students on fractions. *International Electronic Journal of Elementary Education*, 10(5), 591-599. https://doi.org/10.26822/iejee.2018541308

Ashlock, R. B. (2010). *Error patterns in computation: Using error patterns to improve instruction*. *Pearson*.

Bada, S. O., & Olusegun, S. (2015). Constructivism learning theory: A paradigm for teaching and learning. *Journal of Research & Method in Education*, *5*(6), 66–70.

Bian, L., Leslie, S.-J. and Cimpian, A. (2017) 'Gender stereotypes about intellectual ability emerge early and influence children's interests. *Science*, *355*(6323), 389–391. doi:10.1126/science.aah6524.

Black, P., & Wiliam, D. (1998). Assessment and classroom learning. *Assessment in Education*, 5(1), 7-74

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability*, *21*(1), 5-31

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. Jossey-Bass.

Boulet, G. (2007). How does language impact the learning of mathematics? Let me count the ways. *Journal of Teaching and Learning*, 5(1), 1–12

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77-101

Bright, G. W., & Clement, D. H. (2003). Classroom activities for learning and teaching measurement 2003 year book NCTM. *Reston, VA: National Council of Teachers of Mathematics.*

Bruner, J., 1983. *Child's talk*. New York: Norton

Bruno, A., & Martinon, A. (1999). The teaching of numerical extensions: The case of negative numbers. *International Journal of Mathematical Education in Science and Technology, 30*(6), 789-809. https://doi.org/10.1080/002073999287482

Canadian Mathematical Society. (2023, March 31). *Canadian Mathematical Society | CMS-SMC*. CMS-SMC. https://cms.math.ca/

Charles, C. (2020). *Comparing the effects of two inquiry-based teaching strategies on secondary students' conceptual understanding and achievement in mathematics: A mixed-methods approach* [Master's thesis, University of Alberta]. Education and Research Archive. https://doi.org/10.7939/r3-r5p5-6x61

Chen, M., Sun, Y., & Yang, T. (2018). The influence of self-regulated learning support and prior knowledge on learning mathematics. *2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT)*, 265-267. https://1 0.1109/ICALT.2018.00068

Chestnut, E. K., Lei, R. F., Leslie, S. J., & Cimpian, A. (2018). The myth that only brilliant people are good at math and its implications for diversity. *Education Sciences*, 8(2) https://doi.org/10.3390/educsci8020065

Crane, J. (2001). Effects of home environment, SES, and maternal test scores on mathematics achievement. *The Journal of Educational Research*, 89(5), 305-314. https://doi.org/10.1080/00220671.1996.9941332

Davis, E. K. (2016). Cultural influences on Ghanaian primary school pupils' conceptions in measurement and division of fractions. *African Journal of Educational Studies in Mathematics and Sciences*, 12, 1-17.

Del Pinal, G., Madva, A., & Reuter, K. (2017). Stereotypes, conceptual centrality and gender bias: An empirical investigation. *Ratio*, 30, 384–410. http://dx.doi.org/10.1111/rati.12170

Dreyfus, T., Artigue, M., Eisenberg, T., Tall, D., & Wheeler, D. (1990). Advanced mathematical thinking. In P. Nesher & J. Kilpatrick (Eds.), *Mathematics and Cognition* (pp. 113-134). Cambridge University Press.

Duedu, C. B., Atakpa, S. K., Dzinyela, J. M., Sokpe, B. Y., & Davis, E. K. (2005). Baseline study of catholic relief services assisted primary schools in the three northern regions of Ghana. *Cape Coast, Ghana: University of Cape Coast.*

Durkin, K., & Rittle-Johnson, B. (2015). Diagnosing misconceptions: Revealing changing decimal fraction knowledge. *Learning and Instruction*, 37, 21-29. DOI: 10.1016/j.learninstruc.2014.08.003

Egodawatte, G. (2011). *Secondary school students' misconceptions in algebra*. Available from ProQuest Dissertations & Theses A&I. (919730022). https://uml.idm.oclc.org/login?url=https://www.proquest.com/dissertations-theses/secondary-school-students-misconceptions-algebra/docview/919730022/se-2

Fennema, E., Peterson, P.L., Carpenter, T.P., & Lubinski, C.A. (1990). Teachers' attributions and beliefs about girls, boys, and mathematics. *Educ. Stud. Math*, 21, 55–69. http://dx.doi.org/10.1007/BF00311015

Firdaus, F., Zulfadilla, Z., & Caniago, F. (2021). Research methodology: Types in the new perspective. *Manazhim*, 3(1), 1–16. https://doi.org/10.36088/manazhim.v3i1.903

Fischer, J. P., & Ruggiero, M. A. (2007). Strategies for correcting mathematical misconceptions. Childhood Education, 83(5), 287-292.

Fletcher, J. A., Mishiwo, M., & Sedega, B. C. (2014). Junior high school teachers' use of pedagogical content knowledge in teaching and learning mathematics in Akatsi District of Ghana. *Journal of Educational Development and Practice*, 5(1), 61-73.

Franz, D. P., Ivy, J., & McKissick, B. R. (2016). Equity and access: All students are mathematical problem solvers. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas,* 89(2), 73–78. https://doi.org/10.1080/00098655.2016.1165167

Fumador, E. S., & Agyei, D. D. (2018). Students' errors and misconceptions in algebra: Exploring the impact of remedy using diagnostic conflict and conventional teaching approaches. *International Journal of Education, Learning and Development*, 6(10), 1-15

Ghana Education Service. (2024). *Guidelines for the operation of parent associations*. https://ges.gov.gh/wp-content/uploads/2024/01/Guidelines-for-the-operation-of-parent-associations-in-all-pre-tertiary-schools-handbook.pdf

Ghana Statistical Service (2014). Ghana demographic and health survey report. *Accra*. https://dhsprogram.com/pubs/pdf/SR224/SR224.pdf

Golzar, J. , Noor, S. and Tajik, O. (2022). Convenience sampling. *International Journal of Education & Language Studies*, *1*(2), 72-77. doi: 10.22034/ijels.2022.162981

Hattie, J. & Timperley, H. (2007). The power of feedback. *Review of Educational Research*, 77 (1), 81–112, https://doi.org/10.3102/003465430298487

Hayati, R., & Setyaningrum, W. (2019). Identification of misconceptions in middle school mathematics utilizing certainty of response index. *Journal of Physics: Conference Series*, *1320*(1), 012041. https://doi.org/10.1088/1742-6596/1320/1/012041

Hayes, B., & Stacey, K. (1998). *Teaching negative numbers using integer tiles*. Heinemann.

Hedegaard, M. & Chaiklin, S. (2005). Radical-local teaching and learning, a cultural historical approach. *Aarhus, Denmark: Aarhus University Press*.

Henderson Pinter, H., Merritt, E. G., Berry, R. Q., & Rimm-Kaufman, S. E. (2018). The importance of structure, clarity, representation, and language in elementary mathematics instruction. *Investigations in Mathematics Learning*, 10(2), 106–127. https://doi.org/10.1080/19477503.2017.1375354

Hiebert, J., & Grouws, D. A. (2007). The effects of mathematics teaching on students' learning. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (Vol. 1, pp. 371–404). Reston, VA: National Council of Teachers of Mathematics.

Hollander, J. A. (2004). The social contexts of focus groups. *Journal of Contemporary Ethnography*, 33(5), 602–637. https://doi.org/10.1177/0891241604266988

Jamaludin, N. H., & Maat, S. M. (2020). A Systematic literature review on students misconceptions in mathematics. *International Journal of Academic Research in Business and Social Sciences*, 10(6). https://doi.org/10.6007/ijarbss/v10-i6/7273

Jankvist, U. T., & Niss, M. (2018). Counteracting destructive student misconceptions of mathematics. *Education Sciences*, 8(2). https://doi.org/10.3390/educsci8020053

Johnson, H. L., Blume, G. W., Shimizu, J. K., Graysay, D., & Konnova, S. (2014). A teacher's conception of definition and use of examples when doing and teaching mathematics. *Mathematical Thinking and Learning*, *16*(4), 285-311

Jones, J. P., & Tiller, M. (2017). Using concrete manipulatives in mathematical instruction. *Dimensions of Early Childhood*, 45(1), 18-23

Jurdak, M. E. (2018). The nature and prevalence of misconceptions in mathematics among primary school students. *International Journal of Education and Practice*, 6(9), 156-164.

Kieran, C., Booker, G., Filloy, E., Vergnaud, G., & Wheeler, D. (1990). Cognitive processes involved in learning school algebra. In P. Nesher & J. Kilpatrick (Eds.), *Mathematics and cognition* (pp. 96-112). Cambridge University Press.

Knodel, J. (1993). The design and analysis of focus group studies: A practical approach. In D. Morgan (Ed.)*, Successful focus groups: Advancing the state of the art* (pp. 35–50). Thousand Oaks, CA: Sage.

Koch, A. J., D'Mello, S. D., & Sackett, P. R. (2015). A meta-analysis of gender stereotypes and bias in experimental simulations of employment decision making. *Journal of Applied Psychology, 100*(1), 128–161. https://doi.org/10.1037/a0036734

Kruger, L. J., Rodgers, R. F., Long, S. J., & Lowy, A. S. (2019). Individual interviews or focus groups? Interview format and women's self-disclosure. *International Journal of Social Research Methodology*, *22*(3), 245–255. https://doi-org.uml.idm.oclc.org/10.1080/13645579.2018.1518857

Kroesbergen, E. H., & van Luit, J. E. H. (2003). Mathematics interventions for children with special educational needs: A meta-analysis. *Remedial and Special Education*, 24(2), 97–114. https://doi.org/10.1177/07419325030240020501

Kshetree, M. P., Acharya, B. R., Khanal, B., Panthi, R. K., & Belbase, S. (2021). Eighth grade students' misconceptions and errors in mathematics learning in Nepal. *European Journal of Educational Research*, 10(3), 1101–1121. https://doi.org/10.12973/EU-JER.10.3.1101

Kula, S., & Güzel, E. B. (2014). Misconceptions emerging in mathematics student teachers' limit instruction and their reflections. *Quality and Quantity*, 48(6), 3355–3372. https://doi.org/10.1007/s11135-013-9961-y

Kumar, A. (2022). Observation method. *International Journal of Scientific Research*, *13*, 1–14.

Kusmaryono, I., Basir, M. A., & Saputro, B. A. (2020). Ontological misconception in mathematics teaching in elementary schools. *Infinity Journal*, 9(1), 15. https://doi.org/10.22460/infinity.v9i1.p15-30

Lambert, R. (2018). "Indefensible, illogical, and unsupported"; Countering deficit mythologies about the potential of students with learning disabilities in mathematics. *Education Sciences*, 8(72). doi: 10.3390/educsci8020072

Langoban, M. A. (2020). What makes mathematics difficult as a subject for most students in higher education. *International Journal of English and Education*, 9(3), 214-220.

Learning Agency Lab. (2023). *Understanding and addressing misconceptions in mathematics*. Retrieved from Learning Agency Lab website.

Leikin, R., & Zaslavsky, O. (2013). Learning and teaching geometry: Issues, challenges, and opportunities. *Learning through teaching mathematics: Development of teachers' knowledge and expertise in practice,* 197-213.

Leyva, L. A. (2017). Unpacking the male superiority myth and masculinization of mathematics at the intersections: A review of research on gender in mathematics education. *Journal for Research in Mathematics Education*, 48(4), 397–433.

https://doi.org/10.5951/jresematheduc.48.4.0397

Lin, Y. C. (2016). Diagnosing students' misconceptions in number sense via a web-based two-tier test. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(1). https://doi.org/10.12973/eurasia.2016.1420a.

London, M. (2014). The power of feedback: Giving, seeking, and using feedback for performance improvement (1st ed.). Routledge. https://doi-org.uml.idm.oclc.org/10.4324/9781315813875

Major, T. E., & Mangope, B. (2012). The constructivist theory in mathematics: The case of Botswana primary schools. *International Review of Social Sciences and Humanities*, *3*(2), 139-147.

Makonye, J. P., & Fakude, J. (2016). A study of errors and misconceptions in the learning of addition and subtraction of directed numbers in grade 8. *Sage Open*, 6(4). https://doi.org/10.1177/2158244016671375

McLeod, S. (2024, December 6). Can thematic analysis be deductive?. *Simply Psychology*. https://www.simplypsychology.org/can-thematic-analysis-be-deductive.html

Merriam, S. B., & Tisdell, E. J. (2016). Qualitative research: A guide to design and implementation (4th ed.). *San Francisco, CA: Jossey Bass*.

Merriam-Webster. (n.d.). Myth. In Merriam-Webster.com dictionary. Retrieved November 7, 2023, from https://www.merriam-webster.com/dictionary/myth

Ministry of Education (2008*).* Results from Ghanaian junior high 2 students' participation in TIMSS 2007 in Mathematics and Science. Accra.

Ministry of Education (2020). Common core programme: Mathematics curriculum for B7 - B9. Accra: Ministry of Education. Retrieved from https://mickinetsystems.com/wp-content/uploads/2023/01/MATHEMATICS-CCP-B7-B9.pdf

Ministry of Education (2018). National pre-tertiary education curriculum framework: https://nacca. gov.gh/wp-content/uploads/2019/04/National-Pre-tertiary-Education-Curriculum-Framework-final.pdf

Ministry of Education (2019). New standards-based curriculum: Mathematics curriculum for B4 – B6. Accra: Ministry of Education. Retrieved from https://nacca.gov.gh/wp-content/uploads/2019/04/MATHS-UPPER-PRIMARY-B4-B6.pdf

Moss, D. L., Czocher, J. A., & Lamberg, T. (2018). Frustration with understanding variables is natural. *Mathematics Teaching in the Middle School*, 24(1), 10-17.

National Council of Teachers of Mathematics. (2014). *Principles to actions*: *Ensuring mathematical success for all.*

Niesche, Richard. (2009). *The use of home language in the mathematics classroom*.

Ocal, M. (2017). Asymptote misconception on graphing functions: Does graphing software resolve it? *Malaysian Online Journal of Educational Technology*, 5(1).

Olive, J., & Çağlayan, G. (2008). Learners' difficulties with quantitative units in algebraic word problems and the teacher's interpretation of those difficulties. *International Journal of Science and Mathematics Education*, 6(2), 269-292.

Ozkan, M., & Bal, A. P. (2017). Analysis of the misconceptions of 7th grade students on polygons and specific quadrilaterals. *Eurasian Journal of Educational Research*, 16(67). DOI: 10.14689/ejer.2017.67.10

Patrick Friday Obot (2023); Exploring learner's misconceptions in algebraic Problem solving: Insights for effective instruction and assessment; *International Journal of Scientific and Research Publications* (IJSRP) 13(12). http://dx.doi.org/10.29322/IJSRP.13.12.2023.p14429

Pangeni, K. P. (2014). Factors determining educational quality: Student mathematics achievement in Nepal. *International Journal of Educational Development*, 34, 30-41.

Piaget, J. (1977). The development of thought: Equilibration of cognitive structures.*(Trans A. Rosin)*. Viking.

Pretzlik, U. (1994). Observational methods and strategies*. Nurse Researcher*, 2(2), 13-21.

Priya, A. (2021). Case study methodology of qualitative research: Key attributes and navigating the conundrums in its application. *Sociological Bulletin*, *70*(1), 94–110. https://doi.org/10.1177/0038022920970318

Quintero, A. H., & Rosario, H. (2016*). Math makes sense!: A constructivist approach to the teaching and learning of mathematics*. Imperial College Press.

Raj Acharya, B. (2017). Factors affecting difficulties in learning mathematics by mathematics learners. *International Journal of Elementary Education*, 6(2), 8. https://doi.org/10.11648/j.ijeedu.20170602.11

Ramirez, G., Hooper, S. Y., Kersting, N. B., Ferguson, R., & Yeager, D. (2018). Teacher Math Anxiety Relates to Adolescent Students' Math Achievement. AERA Open, 4(1). https://doi.org/10.1177/2332858418756052

Republic of Ghana (2002). Meeting the challenges of education in the twenty first century. *Report of the President's Committee on Review of Education Reforms in Ghana (AnamuahMensah Committee)*. Accra: Ministry of Education

Rittle-Johnson, B., & Schneider, M. (2015). Developing conceptual and procedural knowledge of mathematics. In R. Kadosh & A. Dowker (Eds.), The Oxford handbook of numerical cognition (pp. 1102-1118). *Oxford University Press*.

Roschelle, J., Feng, M., Murphy, R. F., & Mason, C. A. (2010). Online mathematics homework increases student achievement. *American Educational Research Journal*, 47(3), 696-739.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics. In D. Grouws (Ed.), Handbook of research on mathematics teaching and learning (pp. 334-370). *Macmillan*.

Schunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed.). Pearson Education.

Sheffield, L. J. (2017). Dangerous myths about "gifted" mathematics students. *ZDM - Mathematics Education*, 49(1), 13–23. https://doi.org/10.1007/s11858-016-0814-8

Siegler, R. S., & Lortie-Forgues, H. (2015). Conceptual knowledge of fraction arithmetic. *Journal of Educational Psychology*, 107(3), 909-918.

Sisman, G. T., & Aksu, M. (2016). A study on sixth grade students' misconceptions and errors in spatial measurement: Length, area, and volume. *International Journal of Science and Mathematics Education*, 14(7), 1293-1319. DOI: 10.1007/s10763-015-9642-5

Slavin, R. E. (2014). *Educational psychology: Theory and practice* (11th ed.). Pearson.

Spooner, M. (2002). Errors and misconceptions in maths at key stage 2: Working towards success in sats. *David Fulton Publishers*. https://doi.org/10.4324/9780203453728

Stein, M. K., Smith, M. S., Henningsen, M. A., & Silver, E. A. (2009). *Implementing standards-based mathematics instruction: A casebook for professional development*. Teachers College Press.

Stothard, J. (2021) Identifying hidden misconceptions in mathematics. *Journal of the Association of Teachers of Mathematics*,37-39

Stratton, S. J. (2021). Population research: convenience sampling strategies. *Prehospital and disaster Medicine*, *36*(4), 373-374.

Thames, M. H. & Ball, D. L. (2010). What mathematical knowledge does teaching require? Knowing mathematics in and for teaching. *Teaching Children Mathematics*, *17*(4), 220–225.

Uribe-Flórez, L. J. & Wilkins, J. L. M. (2010). Elementary school teachers' manipulative use. *School Science and Mathematics* Journal, 110(7), 363-371.

Üzel, D. (2018). Investigation of misconceptions and errors about division operation in fractions. *Universal Journal of Educational Research*, 6(11), 2656-2662. DOI: 10.13189/ujer.2018.061131

Van de Walle, J. A., Karp, K. S., & Bay-Williams, J. M. (2013). Elementary and middle school mathematics: Teaching developmentally (8th ed.). *Pearson*.

Vermeulen, C., & Meyer, B. (2017). The equal sign: teachers' knowledge and students' misconceptions. *African Journal of Research in Mathematics, Science and Technology Education*, *21*(2), 136-147.

von Glasersfeld, E. (1995). *Radical constructivism* (1st ed.). Routledge. https://doi.org/10.4324/9780203454220

Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes (M. Cole, V. John-Steiner, S. Scribner, & E. Souberman, Eds. & Trans.). *Harvard University Press*. https://doi.org/10.2307/j.ctvjf9vz4

Watson, A., & Mason, J. (2005). *Mathematics as a constructive activity: Learners generating examples.*

Wood D. (1998). How children think and learn: The social contexts of cognitive development (2nd ed.). Blackwell

Yılmaz, Ç., Altun, S. A., & Olkun, S. (2010). Factors affecting students' attitude towards math: ABC theory and its reflection on practice. *Procedia-Social and Behavioral Sciences*, 2(2), 4502-4506. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877042810007603

Yin, R. (2014). Case study research and applications: Design and methods (6th ed.). *SAGE Publications*

Yarkin, K. L., Town, J. P., & Wallston, B. S. (1982). Blacks and women must try harder. *Personality and Social Psychology Bulletin*, *8*(1), 21-24. https://doi.org/10.1177/014616728281003

Zakariya, Y. F., Nilsen, H. K., Bjørkestøl, K., & Goodchild, S. (2021). Analysis of relationships between prior knowledge, approaches to learning, and mathematics performance among engineering students. *International Journal of Mathematical Education in Science and Technology*, *54*(6), 1015–1033. https://doi.org/10.1080/0020739x.2021.1984596

Appendices

Appendix A: Research Ethics Board Approval Letter

University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

PROTOCOL APPROVAL

Effective: June 24, 2024 Expiry: June 23, 2025

Principal Investigator:	Michael Osei-Owusu
Advisor(s):	Christopher Charles
Protocol Number:	HE2024-0147
Protocol Title:	*A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana*

Liz Millward, Chair, REB2

Research Ethics Board 2 has reviewed and approved the above research. The Human Ethics Office (HEO) is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*- TCPS 2 (2022).

This approval is subject to the following conditions:

i. Approval is granted for the research and purposes described in the protocol only.

ii. Any changes to the protocol or research materials must be approved by the HEO before implementation.

iii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.

iv. This approval is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.

v. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.

vi. The University of Manitoba may request to audit your research documentation to confirm compliance with this approved protocol, and with the UM *Ethics of Research Involving Humans*Ethics of Research Involving Humans policies and procedures.

Appendix B: Observation Guide

This observation is a planned component of the research study. It aims to directly observe mathematics teaching and learning in the classroom setting to gain insights into the misconceptions and myths in mathematics and what teachers perceive as the possible factors that contribute to misconceptions and myths. The observation will be conducted in adherence to ethical guidelines and research protocols. Notes will be written, and the focus of the observation is described below.

Observation Plan

During the observation, the following aspects will be observed and recorded:

1. *Instructional Strategies*: The teacher's methods and approaches in presenting mathematical concepts, including examples, demonstrations, and explanations.
2. *Misconceptions and Myths*: Any instances where students demonstrate misconceptions or express myths related to mathematics verbally in the form of communication during the lesson.
3. *Teacher Response*: How the teacher responds to students' questions, misconceptions, and myths during the lesson.

Participants

a. Description

The participants to be observed are teachers and students in grades 7, 8, and 9 during mathematics lessons. Two lessons will be observed from each class. Teachers may select any topic depending on their weekly scheme of learning. The focus will be on typical classroom activities, interactions, and teaching methods used during these math lessons.

b. Ethical Considerations:

Several ethical issues may arise during the observation of students in grades 7, 8, and 9:

- Confidentiality: The identities of the students will be protected. Any data collected will be anonymized, ensuring that no personal identifying information is included in any publications resulting from the study.
- Emotional and Psychological Well-being: Care will be taken to ensure that students do not feel nervous or stressed due to being observed. If any student appears uncomfortable, I will pause the observation and address any concerns.
- Right to Withdraw: Teachers and students will be informed that participation is voluntary and that they have the right to withdraw from the study at any time without any negative consequences. If participants decide to withdraw from the study before December 2024, all observation notes and other participant data will be immediately destroyed. If participants do not withdraw from the study, their data will be destroyed after the study is closed in approximately August 2025. This will be clearly communicated before the start of each observation session.

Consent/Assent

I will obtain informed consent from each teacher, parent or guardian of the students and assent from the individual students. I will explain the purpose of the study clearly to teachers and students, what their participation involves, and that their participation is voluntary.

Appendix C: Individual Interview Guide

This document highlights the guide for the individual interview.

Guide for the Individual Interview

Introduction:

1. Welcome and Introduction
    - Greet participants warmly.
    - Briefly explain the purpose of the study
    - Emphasize the voluntary and confidential nature of their participation.
    - Inform participants of their rights:
        a) to withdraw at any time during the study and that their data will be immediately destroyed when they choose to withdraw before December 2024. If participants do not withdraw from the study, their data will be destroyed after the study is closed in approximately August 2025.
        b) to not answer a particular question.
2. Icebreaker:
    - Conduct a brief icebreaker activity to create a comfortable atmosphere.

Main Questions

3. Misconceptions and Myths
    - What are some misconceptions students have in learning mathematics and how do you clear up these misconceptions?
    - Describe some myths about mathematics learning you have observed in students and the strategies you use to reduce the impact of these myths.

- Reflecting on your teaching experience, what factors contribute to the development of misconceptions and myths about mathematics learning among students?

Closing

- Invite participants to share any additional thoughts or concerns.
- Thank them for their participation and provide information on the study's progress.

Appendix D: Focus Group Interview Guide

Introduction:

1. Welcome and Introduction
    - Greet participants warmly.
    - Briefly explain the purpose of the study
    - Emphasize the voluntary and confidential nature of their participation.
    - Inform participants of their rights:
        c) to withdraw at any time during the study and that their data will be destroyed when they choose to withdraw before December 2024. Inform the participants that if they withdraw from the study after participating in a focus group discussion, their contributions to the group discussion are integrated into the collective data and cannot be withdrawn because withdrawing it will distort the data. If participants do not withdraw from the study, their data will be destroyed after the study is closed in approximately August 2025.
        d) to not answer a particular question.

- Icebreaker
    - Conduct a brief icebreaker activity to create a comfortable atmosphere.

Main Questions

- Misconceptions and Myths
    - What are some challenges students face in learning mathematics, based on your observation? Do you think these challenges are as a result of misconceptions students hold about certain mathematics concepts?

- Can you share some instances where students exhibited misconceptions in certain mathematics concepts?
- Describe some myths about mathematics learning you have observed in students and the strategies you use to reduce the impact of these myths.
- Reflecting on your teaching experience, what factors contribute to the development of misconceptions and myths about mathematics learning among students?

Closing

- Invite participants to share any additional thoughts or concerns.
- Thank them for their participation and provide information on the study's progress.

Appendix E: Assigned Codes and Extracts from Data Supporting Pre-determined Themes

Pre-determined Theme	Excerpt from Data	Assigned Code	Data Source
Misconceptions about Learning Mathematics	*"One misconception is that regardless of whatever variable or unit, they see there, they feel like once it's addition, you are supposed to put things together" (Teacher B, 2024).*	Misconception about variables	Focus group interview
	"How can you subtract 2 from N?" (Student A, 2024).	Subtracting from a variable	Classroom observation (Teacher B's lesson)
	"When you ask them to simplify expressions, all they see is the coefficients" (Teacher A, 2024).	Focus on coefficients	Focus group interview

	"They don't even take their time to look at the measurement units; once they see that they have seen 15 and 20, regardless of centimeter or millimeter, they add (Teacher B, 2024).	Different measurement units	Individual interview
Myths about mathematics learning	*"some were saying that how can a female teach mathematics. So they have that thinking that mathematics is for men. Women or girls are not yet into that domain" (Teacher D, 2024).*	Gender stereotype	Individual interview
	"... like maths is for those who are sharp, those who can think	Mathematics is for the brilliant	Individual interview

	fast" (Teacher C, 2024).		
	"Some of them also think that some people are born with mathematics. So if my mother is good in mathematics, therefore I must also be good in maths" (Teacher A, 2024).	Some people are born with mathematics	Individual interview
	"I will say that learners in general think that mathematics is a difficult subject" (Teacher D, 2024).	Mathematics is difficult	Individual interview
	"Some of them have it that mathematics is boring. Some of them see it that the activities involved are not all that	Mathematics is boring	Individual interview

	encouraging" (Teacher A, 2024).		
	"...they have the idea that you have to memorize formulas. So you memorize formulas for you to be able to arrive at the answer" (Teacher A, 2024).	Mathematics involves memorization	Focus group interview
	"They have in mind that the answer is one way…like whatever you do, there are so many procedures you have to go through to get one answer" (Teacher A, 2024).	Procedural focus	Individual interview
	"2n+4 is the correct answer, 2(n+2) is not" Student (Student M, 2024).	Single answer focus	Observation (Teacher B's lesson)

Factors Contributing to Misconceptions and Myths	*"It's not activity-based… you write and then give exercise. The child is not involved in anything" (Teacher A, 2024).*	Traditional teaching methods	Focus group interview
	"*Not all teachers are trained to teach math, but since he is the class teacher, he has to teach math. Some of them fear maths but the teacher is compelled to teach mathematics, and the student develops that fear (Teacher C, 2024)*	Teacher discomfort	Focus group interview
	"They [male teachers] might be having a conversation with the	Indirect undermining of female mathematics teachers	Individual interview

	learners and mistakenly, not that they wanted to do it but indirectly they would belittle the female math teachers without even knowing that they have even done that" (Teacher D, 2024).		
	"They [family members of students] thought that maths is not needed as such. Especially some of the topics. What are they going to use it for. Let's say the X = 2, what is the X for? What are they going to use that thing for in life? So students also question its	Usefulness of mathematics	Focus group interview

	relevance" (Teacher C, 2024).		
	"My sister has been writing mathematics [exam] for the past five years now without passing… it means this mathematics is very difficult. So this fear gets into the students, and they develop anxiety about mathematics and therefore do not want to pursue it." (Teacher B, 2024)	Student discomfort	Focus group interview
	"Those who previously passed through the system [schooling] have put some fear in others in their family about	Socio-cultural factors	Focus group interview

	mathematics. So they come to the class with that fear" (Teacher B, 2024).		

Appendix F: Approval Letter From Adentan Directorate

GHANA EDUCATION SERVICE

In case of reply, the number and date of this
Letter should be quoted:

My Reference: GES/GAR/AdM./ 4 Vol. 10
Your Ref. No.....
Telephone: [redacted]
E- mail: [redacted]

Republic of Ghana

Adentan Municipal Education Office
Post Office Box AD 2326
Adentan – Accra

30th September, 2024

MICHAEL OSEI-OWUSU
MATER'S STUDENT
UNIVERSITY OF MANITOBA

ATTENTION:
THE HEADTEACHER
[redacted]
ADENTAN

INTRODUCTORY LETTER

We acknowledge receipt of your letter dated 5th September, 2024. The Directorate is pleased to inform you that, permission is granted to Michael Osei-Owusu, a Master's student of University of Manitoba to conduct a research in [redacted] in the Adentan Municipality.

The research topic is on *'A Case of Middle School Students' Misconception and Myths in learning Mathematics', aims to explore the misconceptions and myths about mathematics learning among basic school students, as well as to examine teachers' perception of the factors contributing to these misconception and myths*

Kindly ensure that the research do not interrupt with Instructional Hours.

Thank you.

[redacted]
.....
[redacted]
DIRECTOR OF EDUCATION
ADENTAN MUNICIPAL

Appendix G: Sample Teacher Consent Form

University of Manitoba | Faculty of Education
Department of Curriculum, Teaching and Learning

Faculty of Education – CTL
227 Education Bldg.
71 Curry Place
Winnipeg, Manitoba
Canada R3T 2N2
T: 204-474-9014
F: 204-474-7550

Participant Informed Consent Form

Research Project Title: A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana

Principal Investigator: Michael Osei-Owusu, Master's Student, University of Manitoba, oseiowum@myumanitoba.ca

Research Supervisor: Christopher Charles, Assistant Professor, christopher.charles@umanitoba.ca

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Purpose of the Research: The purpose of this research is to identify some misconceptions and myths that basic school students have about mathematics learning and to examine teachers' perceptions of the factors contributing to these misconceptions and myths.

Procedures Involving Participants: You are invited to engage in observations, individual interviews, and focus group discussions. The study will take 6 hours per participant spread across 4 weeks period. The observation will take 2 hours (2 x 60 min. lesson). The individual interview will take 1 hour for each participant and the focus group interview will take 2 hours. You will take approximately 1 hour to review the transcripts for accuracy. The individual interviews and focus group interviews will take place in person at a time and place that is convenient to you. All interview sessions will be recorded (details below). In the interview, you will be invited to share your perceptions about some misconceptions and myths students have about mathematics learning. As I complete my analysis of your interview, I may email you for clarification of your comments, if needed. You will also be provided a copy of the transcript from your interview, by email, so that you can review and make any changes you wish. You will be given two weeks to review the transcript and provide any changes. If I do not receive a response from you, I will proceed with my analysis using the transcript that I sent you.

Recording Devices: Samsung voice recorder app will be used to record the individual interview and focus group interview with additional backup using the iPhone voice memo app. Recordings will be briefly stored on my password protected Samsung Galaxy phone and iPhone, immediately uploaded to the secure data storage location on University of Manitoba's OneDrive and then deleted from the Samsung Galaxy and iPhone. Access to the University's OneDrive is limited to authorized users and requires multi-factor authentication.

Potential Benefits: Participating in the study offers you a chance to reflect on your own experiences and insights regarding students' misconceptions and myths in mathematics learning. Engaging in discussions about students' misconceptions and myths can contribute to your professional growth as a teacher. It will provide an opportunity to learn from other teachers and gain new perspectives.

Potential Risks: The potential risk of participation in this study is minimal. The probability of

possible harm for you is not greater than you might experience in the conduct of your day-to-day professional life. The activities involved, such as observing mathematics lessons, participating in interviews, and engaging in discussions, pose minimal risks. Your safety and well-being are of utmost importance, and every effort will be made to ensure a comfortable and respectful research environment. You might feel nervous during the classroom observations. There is also a potential emotional risk if you are asked questions during the Interview that bring up difficult experiences you faced when addressing students' misconceptions and myths. If this happens, you will be free to take a break or move to another question.

Disclosure of Abuse: If abuse of children is discovered during the observation sessions, the researcher will immediately report the situation to the head teacher. The researcher and head teacher will intervene to provide comfort to the child as required by law. The head teacher and the School Improvement Support Officer (SISO) will then report the case to legal authorities.

Confidentiality and Anonymity: Any information you share that could be used to identify you will be removed from the transcripts. If you are quoted in articles or conference presentations, a pseudonym will be used. You can choose a pseudonym (only first name is needed) by indicating it here _____. If you leave this line blank, I will choose a pseudonym for you. Any information that could be used to identify other individuals and institutions will also be removed from the transcript.

Participant's contact information, consent letters, audio recordings, and anonymized transcripts will be kept confidential and stored on the University's OneDrive platform. The anonymized transcripts will be stored separate from identifiable data. I, the principal investigator, and my supervisor will have access to this information. The anonymized transcripts will be prepared by the principal investigator using manual transcription. No transcription services or software that involves cloud storage will be used. During the focus group discussion, you may share only what you are comfortable sharing since confidentiality cannot be guaranteed in a focus group setting.

Remuneration for Participating: Snacks will be provided to participants at the beginning of each interview session.

Withdrawal: You can choose to withdraw from the study without negative consequences by contacting the Principal Investigator by email. If you choose to withdraw, the recording and transcript of the session will be destroyed. You will be able to withdraw from the study until the data analysis has taken place. The approximate date after which it will not be possible to withdraw is December 2024. However, given the nature of the research involving focus group interview, there may be limitations to the ability to destroy all data upon participant withdrawal. In focus group discussions, participants contribute to group conversations and interactions. If a participant withdraws from the study after participating in a focus group, their contributions to the group discussion are integrated into the collective data and cannot be withdrawn.

Dissemination of Findings: The analysis of the results and write up will be in my master's thesis. The findings may also be published in academic journals, presented at academic conferences, or included in other scholarly publications. Your personal information will not be included in any publication.

Summary of Findings for Participants: You have the option to receive a short summary of the results of the study. I anticipate that this summary will be available in January 2025. Please select from the responses below to indicate your preferences.

☐ Send me a summary by email to: _____

☐. Send me a summary by regular mail at this address:

_____

Destruction of Data: After the recordings have been transcribed and analyzed, they will be destroyed. The recordings will be destroyed in December 2024. The transcripts, observational data and other identifiable data will be destroyed when the study is closed in approximately August 2025.

Contact Information: You will have the opportunity to ask questions and seek clarification about the study before giving consent. Please feel free to contact the researcher with any questions before signing the consent form or at any time during the study via email at oseiowum@myumanitoba.ca.

Consent Process: If you decide to participate in this study, please sign the consent form and return it to the researcher via email. If you are unable to sign the consent form, please contact the researcher via email.

Consent: *Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.*

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact the Human Ethics Officer at 204-474-7122 or HumanEthics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

Please indicate your consent for each of the following activities by checking the appropriate box:

1. To be audio recorded:
    - ☐ Yes
    - ☐ No
2. To be observed in the classroom:
    - ☐ Yes
    - ☐ No
3. To take part in an individual interview:
    - ☐ Yes

- ☐ No

4. To take part in a focus group discussion:
    - ☐ Yes
    - ☐ No

Participant's Signature: _____ Date: _____

Researcher's Signature: _____ Date: _____

Appendix H: Sample Student Assent Form

University of Manitoba | Faculty of Education
Department of Curriculum, Teaching and Learning

Faculty of Education – CTL
227 Education Bldg.
71 Curry Place
Winnipeg, Manitoba
Canada R3T 2N2
T: 204-474-9014
F: 204-474-7550

Students Assent Form

Title of Research:	A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana
Principal Investigator:	Michael Osei-Owusu, Master's Student, University of Manitoba, oseiowum@myumanitoba.ca
Research Supervisor:	Christopher Charles, Assistant Professor, christopher.charles@umanitoba.ca

This form will inform you about the research study and obtain your permission to observe how you learn and take part in mathematics lessons and use my observations to complete a university assignment. Please read it carefully and feel free to ask any questions before agreeing to participate.

Purpose of the Research: The purpose of this research is to explore some beliefs and misunderstandings that basic school students have about learning mathematics, and to explore teachers' views on the factors influencing these beliefs and misunderstandings.

What Will Happen During the Study: During the study, I will observe your mathematics class to see how you solve mathematics problems and take part in activities during the lesson. You will not be asked to do anything different from your usual classroom activities.

Potential Benefits: The results of this study will give teachers helpful information to recognize and address any misunderstandings students may have about mathematics.

Potential Risks: You might feel a bit nervous during the observation. You will not be identified in any writing so you should behave as you normally do in class.

Disclosure of Abuse: If I see any signs that you might be hurt or in danger during the observations, I will tell the head teacher right away. The head teacher and I will make sure you are safe. After that, the head teacher will tell other adults in charge as the law says.

Confidentiality: I will not collect any personal information about you and will not share any personal information that I might hear or see with anyone.

Withdrawal: You can choose not to be part of this study at any time, and nothing bad will happen. Just tell your teacher, and they will let me know.

Assent: I have read and understood the information above and I am willing to be observed in class as part of the study "A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana." I know I can stop being part of this study at any time if I want to, and if I choose not to join, it will not negatively affect me in any way.

I also know that if I feel uncomfortable at any point during class observations, I can tell my teacher, and they will let the researcher know. And if I have any questions at any time, I can ask.

I know that my parent(s) or guardian must give their permission for me to participate.

Student's Name: _____

Student's Signature: _____ Date: _____

Appendix I: Sample Parental Consent Form

University of Manitoba | Faculty of Education
Department of Curriculum, Teaching and Learning

Faculty of Education – CTL
227 Education Bldg.
71 Curry Place
Winnipeg, Manitoba
Canada R3T 2N2
T: 204-474-9014
F: 204-474-7550

Parental Consent Form

Title of Research: A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana

Principal Investigator: Michael Osei-Owusu, Master's Student, University of Manitoba, oseiowum@myumanitoba.ca

Research Supervisor: Christopher Charles, Assistant Professor, christopher.charles@umanitoba.ca

Your child is invited to take part in a study titled "A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana." This form will inform you about the research study and obtain your permission for your child to participate in this research. Please read it carefully and feel free to ask any questions before giving your consent.

Purpose of the Research: The purpose of this research is to identify some misconceptions and myths that basic school students have about mathematics learning and to examine teachers' perceptions of the factors contributing to these misconceptions and myths.

What Will Happen During the Study: The researcher will observe your child during mathematics lessons. Your child will not be asked to do anything different from their usual classroom activities.

Handwritten Notes: The researcher will take handwritten notes during the observation. The handwritten notes will consist of your child's interactions and what they say during the lesson.

Potential Benefits: The results of this study will give teachers helpful information to recognize and address any misunderstandings students may have about mathematics.

Potential Risks: Your child might feel a bit nervous during the observation. They will not be identified in any writing so they should behave as they normally do in class.

Disclosure of Abuse: If abuse of your child is discovered during the observation sessions, the researcher will immediately report the situation to the head teacher. The researcher and head teacher will intervene to provide comfort to the child as required by law. The head teacher and the School Improvement Support Officer (SISO) will then report the case to legal authorities.

Confidentiality: I will not collect any personal information about your child and will not share any personal information that I might hear or see with anyone.

Withdrawal: Your child can decide not to be part of this study at any time without negative consequences. When they choose not to be part of the study, it will not affect their grades.

Dissemination: The analysis of the results of this study and write up will be in the researcher's master's thesis. The findings may also be published in academic journals, presented at academic conferences, or included in other scholarly publications. No personal information about your child will be included in any publication.

Destruction of Data: Observation notes will be destroyed when the study is closed in approximately August 2025.

Contact Information: You will have the opportunity to ask questions and seek clarification about the study before giving consent. Please feel free to contact the researcher with any questions before signing the consent form or at any time during the study via email at oseiowum@myumanitoba.ca.

Consent Process: If you agree for your child to participate in this study, please sign the consent form and return it to the researcher via email. If you are unable to sign the consent form, please contact the researcher via email.

Consent: *Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.*

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact the Human Ethics Officer at 204-474-7122 or HumanEthics@umanitoba.ca. A copy of this consent form has been given to you to keep for your records and reference.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

I, _____, give permission for my child, _____ to participate in the research project entitled, "A Case Study of Middle School Students' Misconceptions and Myths in Learning Mathematics in Ghana." The study has been explained to me and my questions answered to my satisfaction. I understand that my child's right to withdraw from participating or refuse to participate will be respected and that his/her responses and identity will be kept confidential. I give this consent voluntarily.

Parent/Guardian Signature:

_____ Date: _____

Signature

Researcher's Signature:

_____ Date: _____

Signature