

**INFLUENCE OF MATHEMATICAL SYMBOLS ON THE LEARNERS'
PERFORMANCE: A CASE STUDY OF KOIBATEK SECONDARY
SCHOOLS, BARINGO COUNTY, KENYA**

BY

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DECLARATION

Declaration by Candidate

This thesis is my original work and has not been presented in this University or any other University.

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DEDICATION

This research thesis is dedicated to my loving husband Benjamin, my babies Daphne and Levin, parents Mr. and Mrs. Ronoh, and my siblings Lawi and Emma.

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I wish to thank the Almighty God for the gift of life, the spiritual inspiration, Grace and strength throughout this study. I wish to acknowledge the tireless efforts of Moi university lecturers, my supervisors and friends without whom this study would not have succeeded. My gratitude goes to my supervisors Dr. Rotich Titus and Dr. Mwei Philip, for their technical advice, patience and concern in my study. I cannot forget to thank my family for their encouragement and support.

ABSTRACT

Mathematical symbols are characters or notations used to represent numbers, operations, relations, and other mathematical concepts. These symbols serve as a universal language in mathematics, allowing complex ideas to be communicated clearly and efficiently across different contexts and cultures. Addressing the understanding of mathematical symbols is crucial as it plays a significant role in grasping fundamental mathematical concepts, which can contribute to overall improvement in students' performance. The purpose of this study therefore, was to determine the influence of mathematical symbols on learner performance in mathematics in Koibatek Sub-county. The objectives of the study were: to determine the extent to which mathematics symbols influence students' performance in Mathematics; to determine how various strategies used in teaching mathematical symbols influence students' performance in mathematics; and to find out how the challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem solving procedures influence performance in Mathematics. The study was guided by Constructivist theory which argues that learning takes place when a person is prompted to go beyond current standards of performance and builds new abilities reinforced by previous knowledge and experience. The study adopted descriptive survey research design utilizing mixed method approach. The targeted population was 2800 form three learners from 36 schools and mathematics teachers. The sample size of 350 was calculated using Yamane formula. Students and teachers were sampled using simple random sampling and purposive sampling respectively. To collect data, questionnaires and interview guides were utilized. Quantitative data was analyzed using descriptive statistics, while qualitative data was analyzed thematically based on content of common themes. The analyzed quantitative data were presented in tables inform of percentages and frequencies. The findings of the study revealed that mathematics symbols to a large extent influenced students' performance in mathematics; strategies used in teaching mathematical symbols and challenges students encounter when interpreting and applying mathematical symbols in order to understand mathematical symbols influenced students' performance. The teachers interviewed revealed that among the challenges students face in learning mathematical symbols was poor attitude towards mathematical problems. The study concludes that mathematical symbols to a large extent (73.5%) influenced learner's performance in mathematics. Similarly, various strategies used in teaching mathematical symbols also influenced students' performance in mathematics. Finally, the challenges students in understanding and interpreting mathematical symbols have a large bearing on students' performance in mathematics. The study recommended that, schools should conduct regular assessments to identify students who struggle with interpreting and applying mathematical symbols. Support systems, such as remedial classes and peer tutoring, can be introduced to help these students overcome difficulties and improve their overall mathematics performance. If these recommendations are implemented they will improve students' performance in mathematics.

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CHAPTER ONE: INTRODUCTION

This chapter provides a summary of the background of the study, the problem statement, the purpose, the objectives, the significance, the rationale the scope, and the limitations of the study. In addition, it provides a conceptual framework as well as the operational definition of terms.

1.1 Background of the Study

Mathematics is a discipline of study that promotes logical thinking and reasoning in the context of problem solving, as well as assisting in thinking analytically and improving reasoning abilities. Analytical thinking is the ability to think and reason critically about the world. Mathematics, according to Gouba (2008), is a unique discipline that is acknowledged all around the world. As a result, mathematics is integrated into education in order to provide students with the fundamental skills required for progressing to higher education, pursuing a job route, and maintaining personal living. It serves as the foundation for all of the world's sciences and technology (Uchechi, 2013). Gambari, (2013) observed that mathematics provides a medium for the performance of social functions in our day-to-day activities .It is a subject that contributes significantly to the expansion of individual knowledge and contributes significantly to the enhancement of the socioeconomic development of a nation. A few examples of social functions include buying and selling goods as well as banking. The Association for Computational Mechanics in Engineering (ACME, 2011) concluded that mathematics is an essential component of a well-rounded education and plays an important part in both the business world and the technological world.

Without a solid understanding of mathematics, one's appreciation for a wide range of other educational subjects, such as music, physics, geography, and economics, is put in jeopardy (Vorderman & Noyes, 2019). Mathematics, according to Welberry (2009),

identifies a situation and explains why it exists. In essence, it cultivates knowledge and insight that may be applied to applicable problems or circumstances. Mathematics uses a language full of symbols (Quinnel and Carter, 2012). A symbolic language is one that uses symbols widely or completely, particularly one that was created for the goal of precise formulations. Mathematics symbols form a language that is gradually developed by and for the learner; it is acquired in the same way that any other language is acquired, and it is necessary to translate this language into one's own mother tongue. To make students feel at ease with this language, long periods of training with patience and endurance are required. Mathematics provides good preparation for other sciences by providing training in the use of symbols (Charlesworth, 2015). The symbolic language of mathematics has its own set of symbols, as well as its own set of rules for grammar. We are able to read symbolic expressions in the majority of the mathematical articles (Adams, 2003). In more advanced mathematics, the use of symbols permits flexibility and lightens the mental load.

Teachers use a variety of approaches to handle mathematical symbols effectively with learners. One key approach is explicit instruction, where teachers provide clear and systematic explanations of mathematical symbols. This method involves defining symbols, demonstrating their usage through examples, and guiding students through practice exercises to build foundational knowledge. Research indicates that explicit instruction helps students understand symbols and their applications, particularly for beginners or those struggling with symbol recognition (Hiebert & Carpenter, 2022). To enhance engagement, it is beneficial to integrate interactive elements into this approach. Another significant approach is the use of visual aids, such as diagrams, charts, and interactive displays, which help bridge the gap between abstract symbols and concrete understanding. For instance, graphs can illustrate algebraic equations, and geometric

shapes can demonstrate spatial relationships. Visual aids make symbols more accessible and relatable, benefiting visual learners. However, careful selection is essential to avoid potential confusion (Miller & Koeske, 2020).

Symbolic manipulation practice involves exercises where students actively work with mathematical symbols, such as solving equations or simplifying expressions. This hands-on approach helps develop proficiency and problem-solving skills. Nevertheless, there is a risk that students may focus on procedural aspects without deep conceptual understanding (Kaput, 2018). Thus, combining symbolic manipulation with conceptual explanations is crucial for comprehensive learning. Connecting mathematical symbols to real-world applications can make learning more engaging and meaningful. By demonstrating how symbols are used in practical situations, such as budgeting or engineering, teachers can highlight their relevance beyond the classroom (Boaler, 2002). This approach can increase motivation and understanding, though it requires careful planning to align with educational objectives.

Interactive activities, including group work, mathematics games, and simulations, foster a collaborative learning environment where students explore mathematical symbols together. These activities promote peer learning and active participation but require effective classroom management and alignment with learning goals to ensure productive outcomes (Smith & Stein, 2011). Formative assessment involves using quizzes, concept maps, and informal evaluations to gauge students' understanding of mathematical symbols and adjust instruction accordingly. This method provides real-time feedback, helping teachers identify areas where students need additional support. However, formative assessment can be time-consuming and may not always capture the full extent of student understanding (Black & Wiliam, 2018). Differentiated instruction adapts teaching methods to accommodate diverse learning styles and

abilities. By providing varying levels of support and challenge, teachers can address individual students' needs and enhance their understanding of mathematical symbols. Although effective, differentiated instruction requires significant planning and flexibility from educators (Tomlinson, 2021). Lastly, providing feedback and reflection is essential for promoting continuous improvement. Feedback helps students identify and correct errors, while reflection encourages them to consider their learning processes and strategies. Effective feedback must be timely and specific, and self-reflection activities should be well-structured to be beneficial (Hattie & Timperley, 2007).

Nationally, various interventions aim to improve the teaching and learning of mathematical symbols. Curriculum reforms are a significant intervention, with educational systems revising and updating curricula to address the systematic teaching of symbols. For instance, the Common Core State Standards for Mathematics (CCSS) in the United States provide comprehensive guidelines on teaching mathematical symbols, emphasizing their application in problem-solving contexts (Common Core State Standards Initiative, 2010). These reforms aim to standardize instruction and enhance students' understanding of notation. Professional development programs focus on enhancing teachers' competencies in teaching mathematical symbols. In the UK, the National Centre for Excellence in the Teaching of Mathematics (NCETM) offers training and resources to improve educators' instructional practices (NCETM, n.d.). Such programs equip teachers with effective strategies for teaching symbols and addressing diverse learning needs.

Educational technology integration involves promoting tools like interactive whiteboards and mathematical software to support the teaching of symbols. These technologies provide dynamic ways to represent and manipulate symbols, enhancing understanding through visual and interactive methods (Hennessy, 2013). National

initiatives often fund and support the integration of these technologies to improve educational outcomes. Internationally, several interventions aim to enhance the teaching of mathematical symbols through comparative studies, technological standards, and global initiatives. The International Mathematics and Science Study (TIMSS), conducted by the International Association for the Evaluation of Educational Achievement (IEA), assesses and compares mathematical understanding, including the use of symbols, across different countries. TIMSS provides insights into various educational systems' approaches and offers recommendations for improving instructional practices globally (IEA, 2019).

The importance of mathematics is reflected in its status as a required subject in Kenyan secondary schools, contributing to better academic performance, informed citizenship, professional success, and personal fulfillment (Jablonka, 2003). In a technology-driven society, the ability to use mathematics to interpret complex information and situations is essential. Mathematics finds applications in various fields, including natural sciences, engineering, medicine, and social sciences, as well as in everyday activities like managing finances and making purchases (Neyland, 1994).

Despite its crucial role, students often struggle with mathematics, as evidenced by low performance in the Kenya Certificate of Secondary Education (KCSE) exams reported by KNEC. An important aspect of understanding mathematics is learning its symbolic language. Translation from symbols to words is a critical process in solving mathematical problems (Sepeng & Madzorera, 2014). Symbols such as sum (+), difference (-), product ($\times$), and division ($\div$) are integral to mathematical notation. Understanding and using these symbols effectively is essential for students to solve problems accurately. Without proficiency in both symbolic and instructional languages, students may face difficulties in mathematics.

The challenge of translating mathematical symbols into comprehensible solutions impacts students' achievement in the subject. Therefore, the proposed research aimed to investigate how mastery of mathematical symbols influences learners' performance in mathematics among secondary school students in Kenya. This study was crucial for understanding how proficiency with mathematical symbols can enhance achievement and address the ongoing concerns about low performance in mathematics education.

1.2 Statement of the Problem

Over the years, students' performance in the KCSE Mathematics exam fluctuated, often resulting in poor results. This persistent underperformance raised critical questions: Was the issue caused by students' failure to grasp mathematical concepts, or was it the result of ineffective teaching methodologies? Despite numerous studies and various interventions, a clear, workable solution had yet to be found. This unresolved issue prompted the need for the study, as it appeared that some potential factors influencing students' performance had been overlooked or inadequately addressed.

Several studies had examined factors contributing to poor performance in Mathematics. These included teacher-centered approaches to teaching mathematics, lack of practical modeling activities, insufficient spatial skills, negative attitudes toward mathematics from both teachers and students, high teacher-to-student ratios, high student-to-book ratios, teachers' absenteeism, and the disconnect between primary and secondary school mathematics curricula (Njoroge, 2003; Rukangu, 2003; Miheso, 2012; Amadalo, 2013). In response to these findings, various interventions were implemented, such as the Kenya Education Sector Support Programme (KESSP) and the Strengthening Mathematics and Science in Secondary Education (SMASSE) program, which aimed to address these issues by improving teaching methodologies and reducing class sizes.

However, despite these efforts, students' performance in the KCSE Mathematics exam did not show significant improvement. This raised the question of whether other factors, beyond those already addressed by KESSP and SMASSE, could be contributing to the continued low performance. It was important to critically evaluate whether the previous findings had been fully utilized in the development of interventions or whether new insights could inform more effective strategies. Specifically, the role of mathematical symbols, which are integral to understanding mathematical concepts, may not have been given sufficient attention.

Mathematics relies heavily on symbolic language, and the failure to grasp these symbols could hinder students' ability to learn and apply mathematical principles. Wenno (2015) argued that students' insufficient knowledge of mathematical symbols could be a key factor in their poor performance in national exams. Given the potential significance of this underexplored factor, the study sought to investigate the influence of students' understanding of mathematical symbols on their performance in KCSE Mathematics. The research focused on secondary schools in Koibatek, Baringo County, Kenya, and aimed to provide new insights into how mathematical symbols might have been affecting learner performance.

1.3 The Study's Purpose

The general purpose of the study was to determine the influence of mathematical symbols on learner performance in Koibatek Secondary schools, Baringo County, Kenya.

1.4 The Study's Objectives

The objectives of the study were as follows:

- i. To determine the extent to which mathematical symbols influences students' performance in Mathematics.
- ii. To determine how much various strategies used in teaching mathematical symbols influence students' performance in mathematics.
- iii. To find out whether the challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem-solving procedures affect their performance in mathematics.

1.5 Assumptions of the Study

In conducting this study, the following assumptions were made:

- i. It was assumed that students had been adequately exposed to mathematical symbols in their learning environment, meaning any impact on their performance would stem from comprehension issues rather than unfamiliarity with the symbols.
- ii. The study assumed that teachers were following the prescribed curriculum and using standard instructional methods for teaching mathematical symbols across all Koibatek secondary schools.
- iii. It was assumed that students' performance in mathematics exams accurately reflected their understanding of mathematical concepts and symbols.
- iv. The study assumed that respondents would provide honest and accurate information during data collection, ensuring the reliability of the research findings.

- v. It was assumed that external factors, such as socioeconomic status or available school resources, would have a minimal or constant effect on students' performance, allowing the study to focus specifically on the influence of mathematical symbols.

1.6 Significance of the Research

The study on the influence of mathematical symbols on learner performance addressed a crucial gap in mathematics education research. Despite numerous investigations into teaching methodologies, attitudes towards mathematics, and curriculum content, there had been limited exploration into how students' comprehension of mathematical symbols directly impacted their performance in the Kenya Certificate of Secondary Education (KCSE) examination. This research highlighted how mastery of mathematical symbols played a significant role in learners' success, particularly within Koibatek secondary schools in Baringo County. By illuminating this aspect, the study provided new insights that could influence educational practices and policy formulation.

For students, the findings highlighted the importance of mastering mathematical symbols as a key factor in academic achievement. Understanding and correctly using mathematical symbols could enhance their problem-solving abilities and improve their overall performance in mathematics. The study's results suggested that targeted interventions and focused learning strategies could help students better grasp these symbols, potentially leading to better preparation and higher scores in national exams like the KCSE. This knowledge empowered students to approach mathematics with greater confidence and competence.

Educators benefited from the study's findings by integrating more effective teaching strategies that emphasized the importance of mathematical symbols. The results indicated that teachers needed to adapt their instructional methods to address students' difficulties with symbols and ensure that these concepts were thoroughly understood. Professional development programs and in-service training were tailored to help teachers implement these strategies effectively, ultimately leading to improved student outcomes in mathematics.

Curriculum developers also gained from this research. The study's identification of the critical role of mathematical symbols in learning outcomes informed the development of more effective and targeted curricula. By incorporating specific content and activities that addressed the mastery of mathematical symbols, curriculum developers created resources that better supported students' learning needs. This approach led to the development of more comprehensive and practical mathematics curricula that enhanced students' understanding and performance.

For policymakers and the ministry in charge of education, the study provided evidence to support the formulation of policies that emphasized the importance of mathematical symbols in the curriculum. By incorporating findings into policy decisions, the ministry advocated for educational reforms that addressed this critical aspect of mathematics education. The results guided the development of national strategies and standards aimed at improving mathematics instruction and student performance across the country, not just in Baringo County.

1.7 Rationale of the Study

The rationale for conducting this study was based on the critical role that mathematical symbols played in the learning and performance of mathematics in secondary

education. Since mathematics relied heavily on symbolic language, students' ability to understand and apply these symbols directly influenced their success in solving mathematical problems. In Koibatek Secondary Schools, as in many others, difficulties in grasping mathematical symbols often resulted in poor performance, which negatively affected overall academic achievement and students' attitudes toward mathematics.

This study aimed to explore the specific strategies employed by teachers in teaching mathematical symbols and to evaluate how these strategies impacted learners' comprehension and performance in mathematics. By identifying the challenges students faced and understanding the relationship between symbol comprehension and performance, the study provided insights into how teaching approaches could be improved to enhance mathematical outcomes for learners in Koibatek Secondary Schools. The findings also aimed to inform curriculum development and instructional strategies that could be applied in similar educational contexts.

1.8 Scope of the Study

The study was conducted in Baringo County, Koibatek Sub County. The study's primary goal was to evaluate the influence of mathematical symbols on the learner performance in Koibatek sub county, Baringo County, Kenya. The study's population was restricted to only Form 3 students and was limited to only the teachers of mathematics. The research was carried out between April 2019 and February 2020.

1.9 Limitations of the Study

The study encountered several limitations that affected the quality and generalizability of its findings. Theoretically, the research focused solely on the influence of mathematical symbols on learner performance, which may have excluded other critical factors impacting students' success in mathematics. This narrow theoretical scope

potentially limited the study's ability to provide a comprehensive understanding of the broader educational context and other variables influencing mathematical learning.

Methodologically, the study was restricted to Koibatek Sub-County, which might not have accurately represented conditions in other sub-counties or regions of Kenya. As a result, the findings might not have been generalizable beyond this specific area. Additionally, data collection relied on self-reported information from students and teachers, which could have introduced biases or inaccuracies in the data. Despite assurances to participants that the study was conducted solely for academic purposes, personal views or perceptions might still have affected their responses.

The study's focus on mathematics and its specific geographic scope limited the applicability of the results to other subjects or educational settings. The conditions and practices in Koibatek Sub-County might have differed from those in neighboring regions, necessitating caution when applying the findings to other contexts. These limitations highlighted the need for careful interpretation of the study's results and suggested directions for future research to expand on the insights gained.

1.10 Theoretical Framework

The study was grounded in the theory of constructivism, which significantly influenced the contextualization of the study variables and the overall research process. Constructivism, as proposed by Jean Piaget and elaborated by scholars such as Ertmer et al. (2013) and Arends (1998), emphasizes the active role of learners in constructing their understanding through interaction with their environment. This theoretical perspective was crucial for shaping how the study approached and analyzed the influence of mathematical symbols on learner performance.

By adopting constructivist theory, the study contextualized the variable of mathematical symbols within the broader framework of how learners build and modify their cognitive structures. The theory provided a lens through which the importance of understanding mathematical symbols could be evaluated as part of the learners' broader cognitive development. This approach facilitated the examination of how students' prior knowledge and experiences with mathematical symbols influenced their current performance in mathematics.

The constructivist framework also guided the development of the research design and methodology. It informed the decision to focus on how learners interpret and integrate mathematical symbols within their existing mental models. By recognizing that learning occurs through the interaction between students' existing knowledge and new information (Phillips, 1995), the study aimed to explore how effective use and understanding of mathematical symbols could enhance learners' performance.

Additionally, constructivism influenced the interpretation of findings by emphasizing that knowledge is constructed through individual and shared experiences. This perspective helped in understanding the variability in students' performance and how different students might internalize mathematical symbols differently based on their unique cognitive frameworks.

1.11 Conceptual Framework

Math is a subject that absolutely must be understood by students. Concepts in mathematics can only be expressed using symbolic language. The relationship between these factors is illustrated in figure 1.1.

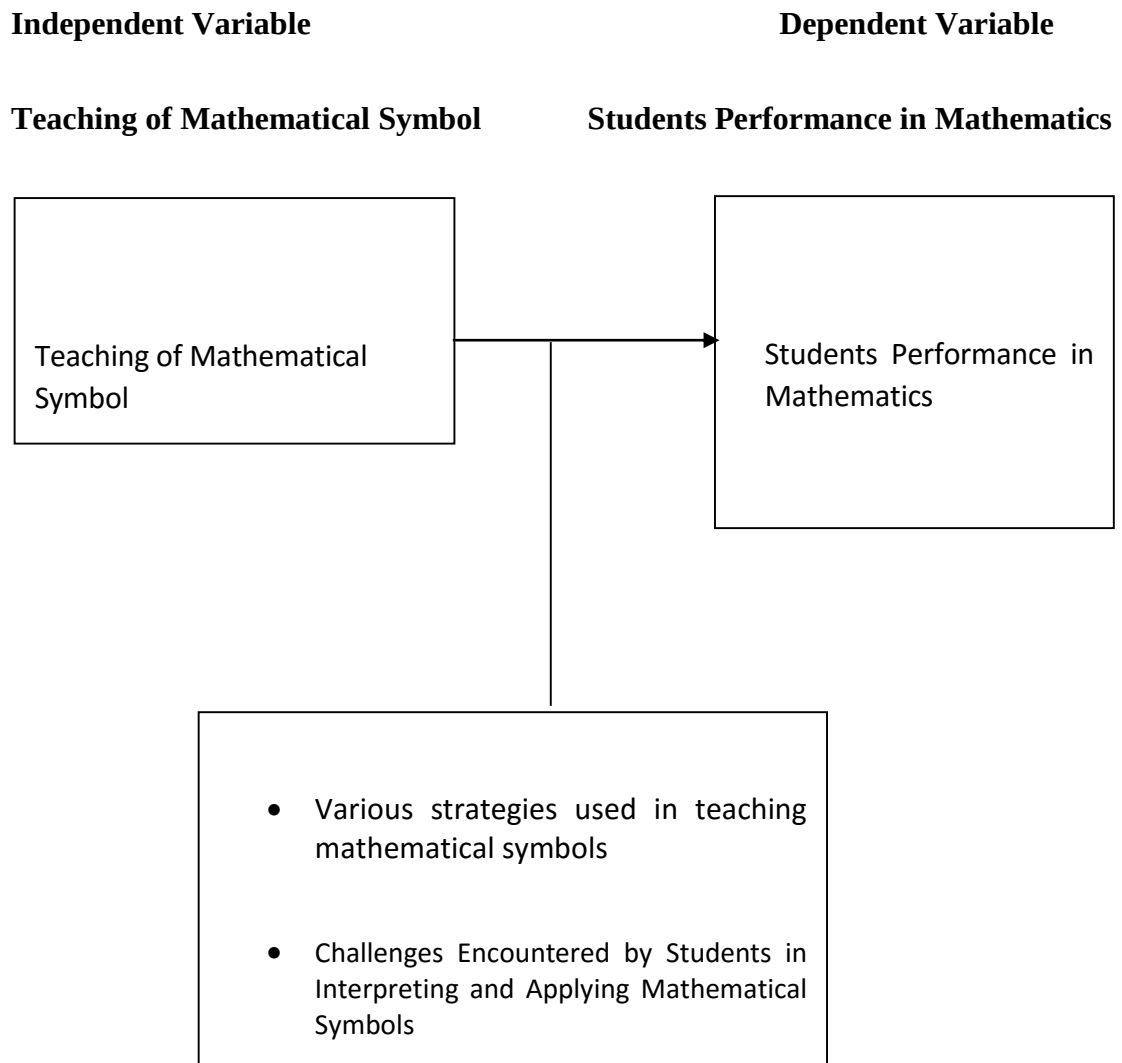


Figure 1: Conceptual Framework

(Source: Researcher, 2019)

Mathematicians rely on symbols to represent mathematical concepts, relationships, and problems in which they work to solve these formats make it possible to find a solution to the problem without having to refer back to the initial scenario. Graphs, symbols, symbols in language, and organizational schemes are all examples of symbolic forms. Diagramming can help you speak, read, and write math. Diagrams help students connect mathematical terms. Learners have battled with mathematics throughout history, from reading to writing to verbalizing. Furthermore, teachers should keep in mind that no single set of approaches is all-inclusive. The list is endless. Learners have

difficulties with formal symbols, a very specific type of mathematical language. Mathematics' specific written symbolism is the most difficult form of language to comprehend. Teachers must be aware of students' struggles in learning mathematics in order to build and develop learning settings that effectively enhance knowledge. When students try to write, read, and articulate the symbolic language of mathematics, they frequently face difficulties.

To solve mathematical word problems well, students must understand the symbols teachers and math specialists use to code problem-solving conditions and context. Teachers should become familiar with the difficulty's students have in the classroom and prepare a list of approaches to address the issues they face in order to enhance their proficiency in word problem.

1.12 Operational Terms of Definition

Academic performance / achievement: Its refers to the progress toward short- and long-term educational goals of a student, instructor, or institution. Academic achievement is the attainment of good scores in a test situation.

Mathematical symbols: Are signs that represent mathematical words like $=$, means equal to.

Mathematics performance: refers to the attainment of scores on assessments, which reflects students' understanding and application of mathematical concepts. In contrast, mathematical literacy encompasses the broader ability to formulate, use, and interpret mathematics in various real-world situations (Williams, 2010).

Symbolic language: Mathematics symbolic language is a one-of-a-kind dialect that uses symbols and grammar rules that are distinct from those used in English. In most Mathematical articles written in any language, we can usually read symbolic language

phrases such as + for addition, = for equality, and $\int$ for integration to represent and solve mathematical concepts and relationships, distinct from everyday language (Esteve, 2008).

Teaching and Learning: Teaching and learning are multifaceted. These elements interact as learners pursue their goals and incorporate new knowledge, behaviours, and skills. In this case, it's teachers and students learning new skills or concepts (Vinner, 2002).

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

This chapter does the review of the literature on various areas of the research issue in order to contextualize the research and establish what other studies have discovered. The researchers looked at unpublished academic theses and papers, government reports and policies, internet research articles, books, journals, as well as other documents.

2.1 Influence of Mathematical Symbols on Students' Performance in Mathematics

Santos and Thomas (2011) define symbolization as linking a mathematical concept to its interpretation.

A symbolic representation is an externally written or spoken sign that represents something else. Symbolization connects the represented and representing worlds, according to Godino & Batanero (2003). Symbolic forms, including line graphs and formal equations remove unnecessary surface aspects and can be flexibly connected to their referents, and more effectively describe the referent's underlying structure. They provide greater flexibility and generalizability across many contexts, but to learners who lack conceptual understanding they may seem as meaningless symbols (Nathan, 2012).

Symbolization can alternatively be described as a way of imparting meanings to mathematical objects and identifying their external representations' relationships with them (Thomas, 2003). Teachers and other math specialists utilize symbols to encode problem-solving scenarios and context into symbolic forms. Organizational schemes, symbols, graphs, and language are examples of symbolic forms or representations that define a notion and allow the problem to be handled without going to the circumstance in which a real-life problem exists. Symbolization is embedded in the ability of a

student to engage well with outside world, according to Kollár (2014). Symbolization as per Fiorini, Gärdenfors, & Abel, (2014), creates mental structures, which the mind then acts on to create mental or cognitive structures. As a result, the linkage of mental operations with mathematical symbols evolves the meanings of mathematical concepts (Kvasnika, 2008). Mathematical symbols are used to illustrate and describe the structure of mathematical concepts, as well as to perform operations such as subtraction, addition, multiplication and division according to Steinbring, 2006). The symbols of mathematics enable teachers to convey math's concepts concisely and assist students in making mathematical reflections. Mathematical symbols provide permanent expression of cognition and solution processes (Rubenstein & Thompson, 2001). Mathematical symbols, according to Ganesalingam (2013), are characters in mathematical statements that have been written down that are essential for the formation of knowledge of mathematics. Mathematical statements that have been written is distinct from other sciences in that it contains a large number of symbols. Farrugia (2013) also highlights mathematics' symbolic aspect as the subject's most visible and distinguishing quality. When students try to write, read, and verbalize the symbolic language of mathematics, they frequently face difficulties.

Mathematical symbols are fundamental to students' understanding and performance in mathematics. Recent research continues to underscore their importance. A research by Miller and Koeske (2020) highlights that students' performance in mathematics is closely tied to their ability to interpret and use mathematical symbols accurately. Their study demonstrates that students with a strong grasp of symbolic notation tend to perform better in complex problem-solving tasks, suggesting that symbol comprehension is critical for mathematical achievement.

McNeil and Alibali (2018) conducted an in-depth study on the role of mathematical symbols in cognitive processes related to problem-solving and student performance in mathematics. Their research revealed that students who effectively use and understand mathematical symbols exhibit a higher likelihood of succeeding in more advanced mathematical topics. This success is attributed to the symbolic representations acting as cognitive tools that aid in the organization and processing of mathematical information. According to McNeil and Alibali, symbols are not merely abstract entities but are integral to the cognitive framework that supports complex problem-solving. They facilitate the mental manipulation of mathematical ideas and relationships, allowing students to develop and apply sophisticated problem-solving strategies. The ability to interpret and utilize these symbols effectively enhances cognitive efficiency and contributes significantly to students' overall mathematical performance.

In a related study, Jansen and Sälzer (2021) explored how symbolic notation impacts students' mathematical performance with a focus on the depth of their understanding. Their findings underscore the critical role of a thorough comprehension of mathematical symbols in handling abstract concepts and solving problems efficiently. Students who possess a profound understanding of symbolic notation are better equipped to tackle complex mathematical tasks that require abstract thinking. Jansen and Sälzer's research highlights that a robust grasp of mathematical symbols enables students to make meaningful connections between abstract ideas and practical problem-solving approaches. This deeper understanding supports the notion that symbolic comprehension is essential for mastering higher-level mathematics and aligns with previous research emphasizing the importance of symbolic literacy in achieving academic success in mathematics.

2.2 Strategies Used in Teaching Mathematical Symbols and Their Impact on Students' Performance

Instructors must be informed on various challenges the use of symbols poses to students. The symbols are concise, abstract, specialized, and formal type of mathematical expression. Mathematical symbolism is mostly restricted to the classroom. As a result, frequent, rich, meaningful, and gratifying opportunities to utilize that language must be provided. Learning should progress from tangible to abstract, according to Bruner (1960). Although mathematical symbolism and understanding are inextricably linked, meaning must always come first (Rubenstein & Thompson, 2001). The inactive stage is when teachers engage students in situations, challenges, and tasks which transition the learners through known to unfamiliar Maths concepts. The iconic level presents result in tables or graphics. The symbolic stage represents learning in written English with mathematical symbols and in spoken English with mathematical language.

Mathematics teachers must verbalize whatever they write and use mathematical language with precision and fluency. When learning mathematical concepts, it is critical for all students to use and diverse senses as possible. They must read, write, listen to and tactically explore a new mathematical issue using manipulatives, as well as move their body together with the manipulative around when possible.

The low mathematics performance by South African students could be linked back on the techniques employed when instructing Maths in primary schools (Siyepu, 2013). The emphasis is on individual challenges rather than the theoretical foundations required for higher-level understanding of generic mathematics (Wilson, 2006). Only a program on mathematics that teaches concepts, skills, and problem-solving can lay these foundations (Daro, 2006). The mathematics education reform movement began

in the mid-1980s as a reaction to the failure of conventional methods of teaching, the effect of technological advancement on curriculum, as well as the rise of newer strategies towards the research on mathematics learning. (Battista, 1999). Students must be in a position to write, read and debate math, as well as engage in rigorous mathematical and logical discussions using demonstrations, drawings, and real-world objects. Mathematical learning that is meaningful is the result of intentional involvement and engagement which improves on existing knowledge as seen by Romberg, (2000).

Clements and Sarama (2019) conducted their research in the United States, focusing on the effectiveness of explicit instruction in teaching mathematical symbols. Their findings emphasize that clear and systematic explanations significantly enhance students' comprehension and application of these symbols. Explicit instruction, which involves breaking down mathematical symbols into their fundamental components and providing structured guidance, helps students build a solid foundation. This approach not only improves students' ability to interpret and use symbols effectively but also contributes to better problem-solving skills.

Huang et al. (2020), in their study conducted in Taiwan, explored the impact of visual aids such as diagrams and interactive software on the understanding of mathematical symbols. They found that visual representations are crucial for bridging the gap between abstract symbols and concrete understanding. By depicting relationships and operations visually, these aids make complex symbols more accessible and comprehensible. This approach enhances student engagement and supports deeper learning by making abstract concepts more tangible.

Bakker et al. (2022) investigated the role of educational technology, including interactive whiteboards and mathematical software, in the Netherlands. Their research highlights how these technologies improve student engagement and comprehension of mathematical symbols. Interactive environments allow students to manipulate symbols dynamically and receive immediate feedback, which helps them develop a more intuitive understanding of mathematical concepts and applications.

Sullivan et al., (2021) conducted their research in Australia, demonstrating the effectiveness of connecting mathematical symbols to real-world applications. Their findings show that relating symbols to practical contexts increases students' motivation and understanding. By illustrating how mathematical symbols apply to everyday situations, students see the relevance of their learning, which enhances their engagement and performance in mathematics.

Hattie and Timperley (2021) reviewed formative assessment practices in the United Kingdom, emphasizing the importance of timely and specific feedback. Their study found that formative assessment is crucial for monitoring students' understanding of mathematical symbols and improving their performance. Providing constructive feedback helps address individual learning needs and correct misunderstandings, leading to better comprehension and application of mathematical symbols.

Sabean and Bavaria (2005) produced a checklist comprising important learning and teaching principles in mathematics. The instructors are required to know what students ought to learn depending on their own knowledge, according to the list. Teachers conduct questions that focus on building understanding of the concepts, students give written rationale for solution of problems, the exercises concentrate on skills together with concepts, the math curriculum promotes the understanding of concepts.

According to the study, teachers divided their teaching methods into three categories: co- instructional, pre-instructional, and post-instructional. They located all three pre-instructional tactics that teachers employed before assigning the task, which were the grouping of students into smaller groups, outlining the task's aim, and distributing readings of the task. Since they inspired, informed, directed, and encouraged the students to investigate the suggested activity, this collection of tactics boosted the task's early growth. The purpose of this study was to determine whether teaching techniques were grouped under the same heading and what specific tasks were designed to promote pre-instructional tactics.

During the task, the second tradition of co-instructional teaching techniques was applied. This tradition of teaching methods included a wide variety of methods, including the use of unconventional questions, elevating student collaboration, using analogies from real-world situations, establishing the legitimacy of the students' answers, emphasizing everyday expressions over mathematical reiterations, and providing hints through the task. At this point, how these strategies are used depends on the teaching methods.

The third set of instruction was post-instructional and involved locating strategies like socializing the assignment and dispelling doubts. These two concepts go hand in hand because it was through socializing the assignment that the students were able to express their various doubts regarding its progress. at this study, the researcher learned how math instructors structured their lessons at the secondary schools in Bahati Sub-County.

McAfee (2012) conducted a study at Western Oregon University on teaching techniques for the high school mathematics classroom, concentrating on two techniques: inquiry-based learning (IBL) and the use of real-world examples. The study

concentrated on the development of two distinct lesson plans, one of which employed real-world examples and the other inquiry-based learning. IBL and real-world example tactics, in the researcher's opinion, can be used in the majority of mathematics classes in middle or high school. Students are enthusiastically involved in their learning through the IBL approach and real-world applications, which enables them to design effective learning experiences. Further research from this study revealed that IBL's effective mathematics and science teaching and learning practices foster the fundamental abilities that support learners' growth as creative, optimistic, and autonomous individuals. The results of using IBL and a real-world example pushed the researcher to consider if the teaching methods utilized in Bahati Sub-County enabled students to be imaginative, upbeat, and independent when solving mathematical problems.

Another study conducted in Kenya by Kathare (2012) examined the impact of instructional strategies on math achievement among students with hearing impairment in Meru County. The study's foundation was Burrhus Fredric Skinner's theory of learning motivation. A descriptive survey design served as the study's direction. Head teachers, quality assurance and standard officials, and teachers instructing math to students with hearing impairments made up the target population. Purposive sampling was utilized by the researcher to select individuals from the population. Questionnaires, interviewing protocols, and checklists for observation were used to gather the data. During the piloting phase, the reliability was examined using the test-retest method. Field data was gathered and then organized, coded, and analysed using tables, charts, frequencies, percentages, and text.

According to the report, teachers employ interactive teacher-learner strategies like peer tutoring to help students who are having trouble with a particular area of mathematics.

Effective communication and the availability of learning resources made these interactive techniques viable resources for instruction, efficient training, and pupil behavior. The research helped greatly in this study since it made it easier for the researcher to examine if the languages used to present mathematical concepts have any impact on students' performance.

Researchers Cordero, Cristobal, and Gil (2015) divided traditional instruction based on repetition, lecturing, and memorization from contemporary dynamic learning, which supports student engagement in their learning through practices like group work, use of communication technology, and student self-assessment. The study was conducted in Madrid, Spain. The study used teacher questionnaires to collect data on their backgrounds and teaching practices. The results show that while contemporary teacher-centered tactics have a less positive and concentrated effect on high achievers, traditional teacher-centered strategies have a positive and considerable impact on student progress. The outcome of this study appears to be in favor of teacher-centered learning techniques, particularly for underachievers. The purpose of this study was to identify the mathematics teaching strategies that were employed and the rationale behind each strategy's adoption in various schools.

With a focus on teaching techniques, styles, and activities that were helpful in higher education, Sarode (2018) addressed important attributes of a successful teacher in a desk research study on teaching strategies, styles, and qualities. The study recommended several categories of teaching tactics, such as efficient teaching methods, a balanced and integrated curriculum, and the use of digital technologies in the classroom, to improve the quality of higher education. Teaching strategy, and best practices in the classroom. The study also found that training varied between instructors as well as between pupils. For example, the authority or lecture style, the facilitator or

activity style, the delegator or group style, and the hybrid or blended style are all common teaching methods. Even though the study was conducted in higher education, it aided the researcher in learning more about the instructional techniques used in secondary school, particularly with regard to their efficiency, integration, and efficacy in teaching mathematics.

A study on the effects of the Collaborative Concept Mapping (CCM) teaching technique on secondary school students' development of the cognitive and affective domain was undertaken by Bomet, Bii, Mukwa, and Too in 2019. The study specifically looked for any changes in students' views toward utilizing the CCM teaching strategy, conventional methods of instruction, gender- and group-based student accomplishment in mathematics. The constructivist theory, which sees students as active creators of meaning from input by processing it through pre-existing cognitive structures and preserving it in long-term memory, served as the study's theoretical framework. The Solomon Four-Fold research design was used for the investigation. Three students and four randomly chosen mathematics teachers made up the sample, which included 161 people. Data were gathered using the Students' Attitude Toward Mathematics Questionnaire (SATMQ).

ANOVA, means, and t-test were used in data analysis instead of descriptive and inferential statistics. According to the researchers, when students are taught utilizing the CCM teaching technique as opposed to the conventional method, the level of attainment in the attitude toward mathematics and learning of mathematics scored higher. The researcher believed that gender had little bearing on the chosen teaching method. These results are crucial to this study since they enabled the researcher to compare the traditional approaches used by educator and CCM techniques. The study

assisted the researcher in determining how the students felt about the instructional techniques employed by their teachers.

A descriptive study on teachers' preferred math educational approaches and strategies was conducted in Turkey by Ünal (2017). The study's goal was to identify teachers' preferred pedagogical approaches and teaching strategies for mathematics. Where a primary case study technique was used, a qualitative research design was adopted. During the academic years 2015–2016, the researcher randomly chose 40 teachers from various secondary schools. Semi-structured interviews were used to get the information. The purpose of the assessment determined the research's validity, and identifying the data source explicitly ensured its reliability. Participants' opinions were separated into groups and subgroups and analyzed using a categorical descriptive analysis technique. Quotations were utilized to guarantee that viewpoints were accurately expressed.

The analysis showed that methods that were relatively simple to employ, such as "Question and Answer" and "Demonstration," were preferred by teachers. Techniques like "Scenario" and "Case Study" were out of date since they called for more thorough research and the use of educational resources. This research by Ünal (2017) is significant because it will inform this study's choice of qualitative methodology and aid the researcher in examining the efficacy of the "Question and Answer" and "Demonstration" approaches in the teaching and learning of mathematics. On the other hand, this study solely paid attention to "Question and Answer" and "Demonstration". The focus of this study was on how these instructional methods contributed to improving student performance, however this was not examined.

A research by Mukelebai and Marvin (2020) in Zambia evaluated the impact of math instruction methods on students' performance in senior secondary maths. The specific goals were to evaluate the various mathematics teaching methodologies, examine students' performance in mathematics at the senior secondary school level, identify the difficulties students face in mathematics in grade 12, and ascertain the government's role in easing those difficulties through the ministry of general education.

The target population for the study, which used a case study research design, was 83 people, including 40 students, 30 parents, 8 instructors, 4 head teachers, and a DEBS officer. While parents and students were chosen using simple random sample, the study used selective sampling to pick the head teachers, DEBS, and teachers. A questionnaire and interview guide were used as the main methods of gathering data from respondents. Secondary information was gathered online from books, journals, and other sources. While the closed-ended responses were examined using Anova and the statistical software version 20, the open-ended responses were examined thematically.

The study's findings demonstrated that although teachers used a variety of strategies to teach mathematics, including inquiry, discovery, group work, and demonstration, they frequently started lessons without drawing on the students' past knowledge to make the connections between earlier lessons and the new mathematical skills. As a result of this type of teaching methodology, we observed that the learners computed at a very low pace that was tedious and laborious. Although the strategies were sound, the way they were applied did not result in the pupils performing well. The study's findings also indicated that a person's home environment, the availability of textbooks in such environments, their reading habits, and the teachers' methods of instruction all contributed to poor arithmetic performance. This study supported the investigation of

how well teaching methods affected students' math performance in the Bahati Sub-County. Despite the fact that the study's recommendation was the

In a study on students' math performance and self-efficacy beliefs in a setting with several assessment tasks, Pagtulon-an and Tan (2018) looked at Asia. The study's goal was to look into how well students performed in arithmetic and their perceptions of their own abilities in a rich assessment tasks environment (RATE) at Central Mindanao University Laboratory High School. The intended audience consisted of eighth graders. The study employed a quasi-experimental research design in which the experimental group participated in rich assessment tasks whereas the control group did not. Before the experiment began, pre-tests on math and self-efficacy beliefs were administered to students in both groups. A questionnaire was employed as the research tool. The data were analyzed using descriptive statistics and analysis of covariance (ANCOVA).

According to the research's findings, students in both groups performed poorly on their pre-tests but significantly better on their post-tests and retention tests following the intervention period. Both before and after the intervention, students were seen to have optimistic views of their own efficacy. Students exposed to RATE outperformed those exposed to non-RATE, according to the covariance analysis. The study came to the conclusion that RATE might boost the low- performing pupils' performance and self-efficacy views. In contrast to the current study, which utilized a cross-sectional survey methodology to examine students' mathematical performance and the tactics employed to teach it, Pagtulon-an and Tan's (2018) study used an experimental approach to examine the effects of RATE on student performance as well as self-efficacy. Despite the fact that the study examined how students' self-efficacy improves their performance, it was crucial in Alzahrana and Stojanovskia's study on the assessment of mathematics teaching methodologies in Australian high schools was done in Australia in 2019.

Classroom management, student- teacher relationships, teacher support, cognitive engagement, climate of discipline, formative assessment, teacher-directed instruction, and student orientation were among the teaching-related topics examined in the study. Parental economic position and educational attainment were also taken into consideration as potential performance stimuli and were found to have notable effects on mathematics performance, with pupils whose parents had higher levels of education generally achieving better outcomes.

According to Alzahrana and Stojanovskia's (2019) research, the cognitive activation of student- teacher relationships, vignette classroom management, and disciplinary atmosphere were all found to significantly improve math performance. Student orientation had a noticeable detrimental impact on math performance, and using it more frequently was linked to worse math accomplishment. The findings of this study can provide important insights into how teaching methods can be enhanced to boost students' mathematical performance by working in tandem with other elements.

Arends, Winnaar, and Mosimege (2017) conducted a study in South Africa that examined teacher classroom methods and students' math performance in South African schools: A reflection on TIMSS 2011. The study employed a two-stage stratified systematic sampling design, with intact grade nine classes randomly chosen at the second stage and schools chosen based on probability to size at the first stage. The information was gathered utilizing questionnaires that categorized information regarding teaching techniques such as collaboration, feedback, formative assessment, feedback to students, and clarity in the classroom. According to the research findings, there is a correlation between learner achievement and teachers' strong support of the chosen classroom strategies. Despite looking at high recommendation, this study didn't examine how instructional methods might improve kids' math ability. The impact of

low recommendation on kids' math performance was also not examined in the study. This study examined how teaching methods in secondary schools in Bahati Sub-County are affecting students' math performance.

Akanmu, Abinde, and Fajemigadba (2014) conducted research on teaching methods and junior secondary school students' mathematics performance in Nigeria. In senior secondary schools, the study examined teacher-teaching methods and students' mathematical performance. Data was gathered using a quasi-experimental methodology and a mathematics academic performance test with five items of theoretical questions on basic equations and a variant taken from the past questions of the West African Senior School Certificate Mathematics Examinations.

The study's findings showed a substantial difference favoring those who were exposed to simulation method as opposed to those who were taught utilizing simulation method. The study's findings demonstrated that, regardless of whether students' academic performance was inadequate or not, the simulation teaching method was advantageous to all ability levels. The study suggested using the simulation technique of instruction to teach only straightforward equations and variations rather than additional mathematical ideas. In their 2014 study, Akanma, Abinde, and Fajemigadba examined junior secondary school mathematics instruction and student performance. Although the current study on teaching strategy and students' mathematics performance was highly explicit on the tactics employed, the previous study did not identify the teaching strategies that were used for simulation.

Awoniyi and Butakor (2021) did a study on the impact of the teacher-student interaction on the mathematics performance of the eleventh graders in Ghana. Cape Coast's largest city. The study concentrated on a factor in the teacher-student connection that could

affect how well the eleventh grade performed. 2,575 students were selected at random to make up the sample size for the questionnaire on the relationship between the teacher and pupils and the mathematics achievement test.

Results showed that unhealthy context and challenge significantly (but not statistically) connected with accomplishment scores, but support did not. Trust, fear, and a lack of respect did not significantly (but negligibly) correlate with achievement scores. Together, the sub-constructs and achievement scores differed by about 8%. Pre-service and in-service training on the teacher- student connection are necessary if we are to foster critical thinking and democratic future leaders. The study examined the impact of the teacher-student interaction on students' math performance. The goal of the current study was to focus primarily on the mathematics instruction methods used by teachers and student achievement in Bahati Sub-County secondary schools.

Gichuru and Ongus (2016) conducted a study in Rwanda on the impact of teaching quality on learners' performance in mathematics during the primary 6 national exams. The sample size of 63 mathematics instructors, 28 head teachers, and 302 students was chosen using a multi-stage random sampling procedure and a correlation comparative study design. Communication abilities, teacher readiness, teacher qualification, teacher practice, teacher experience, and teaching practice were five teacher attributes that were examined. A correlational and comparative research design was used in the study. Data collecting tools included questionnaires and interview instructions. Multiple regression analysis, frequencies, weight means, standard deviations, and percentages were used to analyze the data. A content analysis was conducted on the interview guide. Statistical Package for the Social Sciences Version 21.0 (SPSS V.21.0) software was used to analyze quantitative data.

According to the research results of Gichuru and Ongus (2016), it was shown that teachers who used effective teaching strategies had students perform better than those who used ineffective strategies. Furthermore, more experienced teachers have an impact on students' performance than less experienced educators. Additionally, better communication among teachers was associated with better student performance. Arithmetic performance improved at schools where teachers were devoted to their jobs, had a favorable attitude about arithmetic, prepared thoroughly before class, used a lot of current teaching resources, and engaged their students through evaluation and assessment. The current study was interested in examining how teaching tactics had affected students' mathematical performance, but it also looked at how good practices and traits had benefited students' performance.

Mbugua, Kibet, Muthaa, and Nkonke (2012) looked examined the reasons that might be causing pupils in Baringo County, Kenya, to do poorly on math exams for the Kenya Certificate of Secondary Education. The study established the tactics that may be utilized to increase performance in mathematics and their influences that affect performance in mathematics. It also identified the school-based characteristics that influence students' mathematics performance in secondary schools. The study used a descriptive survey research design. The intended audience consisted of 1876 respondents, including 132 math instructors, 9 head teachers, and Form Three secondary school students in the Koibatek District. Three questionnaires—one for head teachers, one for students, and one for teachers—were used to gather the data for the study.

According to Mbugua, Kibet, Muthaa, and Nkonke's (2012) study, poor performance was a result of students' and teachers' negative attitudes, a lack of suitable learning and teaching materials, and degrading practices. To correct this bad performance, the

neighborhood needed to be made aware of and prepared to reject behaviors that prevent students from participating effectively in the study of mathematics. While the current study examines teaching practices and student mathematics performance in Bahati Sub-County, the previous study examined how school- related factors affected student mathematics performance.

Wekesa (2013) conducted a study in Kenya on the variables influencing students' arithmetic performance at the KCSE level in Kakamega County secondary schools. Bruno's idea of knowledge and organization served as the study's foundation. The study used a survey methodology, and information was gathered through the use of questionnaires, observation schedules, and interview schedules. Descriptive statistics were employed for analysis once the data had been manually coded. In order to analyze the data and determine the correlation coefficient of each independent variable on the stepwise multiple regression analysis as well as the interactive effect of independent variables, the statistical software for social sciences SPSS was used. Prior to starting the actual research, a pilot study was utilized to verify the suitability of the research instruments. The research used the split-half approach to assess the instrument's reliability, which resulted in a score of $r = 0.78$. Both qualitative and quantitative data were gathered, and the results were presented using descriptive narrative, percentages, and frequencies.

According to the study, the teacher's degree of instructional tactics, classroom readiness, and practice all have a significant favorable impact on the students' academic achievement in mathematics. The study also showed that how other students perceived the topic had a significant impact on a student's personality and attitudes about mathematics. Additionally, the choice of a teaching technique is significantly influenced by the teacher's experience. Student performance in mathematics was not

significantly impacted by the student-teacher or student-textbook ratios. The study's findings suggested that teachers rarely included a variety of learning activities in their mathematics sessions and that their instructional tactics and methods were inefficient and unproductive. By demonstrating how teacher traits, attitudes, and lesson planning have an impact on students' mathematics performance in secondary schools in Bahati Sub-County, a study by Wekesa (2013) shed more light on this study. However, this study will not examine how students' academic performance is impacted by the personalities of mathematics teachers.

Odiembo and Simatwa (2014) conducted a study in Muhoroni Sub-County, Kenya, investigating the association between the gender and age of secondary mathematics teachers and pupils' math achievement. Both a descriptive survey methodology and a research design based on correlation were used. A sample size of 21 principals, 31 math teachers, and 300 form four students were chosen using saturation and random sampling, respectively, from the research population, which included 22 principals, 41 math teachers, and 1344 form four students. Interview schedules, document analysis guidelines, and questionnaires were all part of the data collection tools. While the qualitative data were transcribed, evaluated, and presented in emergent themes and sub-themes, the quantitative data were analyzed using descriptive statistics and inferential statistics.

According to the study, an individual teacher's competency, commitment, and responsibility mattered more than their age much more than their ability to instruct. When compared to senior teachers, some younger teachers were shown to perform better because they were able to build strong relationship with their students. It was also revealed that younger teachers tend to be more enthused about their subject matter and have a more current understanding of it than older ones.

However, given their youth, they might not be taken seriously by students, which would put them at a disadvantage as math instructors. The researchers concluded that male professors outperformed female teachers in teaching mathematics because they used their stamina to emphasize their authority as the majority of pupils despise math and look for numerous justifications for their low performance. The goal of this study is to determine whether students' math performance varies depending on the age and gender of their math teachers. It also examined the impact of teacher-student relationship on how well students understood the subject of mathematics. This enlightens the researcher to consider how effective teaching tactics for raising performance in the subject could result from a positive relationship between the teacher and the students. The study, however, could not demonstrate how responsibility, competence, and dedication could influence the decision to select effective mathematics teaching methodologies.

A study on improving math performance for students with hearing impairment in primary schools was carried out in Kenya by Mwololo (2017). The 28 students with hearing impairment from classes 1 through 8 made up the target population, together with the 9 teachers. Math teachers and students in grades 5-8 who were old enough to be questioned and provide the necessary information were purposefully sampled by the researcher. An interview schedule and a questionnaire were created in order to gather information from hearing-impaired students and math teachers, respectively. The Statistical Package for Social Sciences (SPSS) was used to analyze both quantitative and qualitative data to provide descriptive statistics like percentages, frequencies, and tabulations.

The study discovered that teachers were instructing students in classes 5-8 who had hearing impairments in mathematics using gestures rather than a variety of instructional

strategies, which are essential for improving students' overall comprehension of mathematical concepts and ultimately improving their performance in the subject. It was also discovered that, despite their credentials in special needs education, the majority of math teachers had trouble translating mathematical concepts into sign language. Similarly, due to their poor mathematical background, students with hearing impairment found it challenging to understand mathematical sign language vocabulary. The study recommended that engaging teaching strategies be used to pique students' interest in arithmetic, and that frequent in-service trainings for math teachers be provided for students in classes 5-8 who have hearing impairments. Additionally, it suggests taking steps to boost teachers' motivation as well as conducting appropriate follow-ups on instructional strategies and materials. Although the study was conducted with hearing-competent students, it was necessary to conduct a similar study with students who are not physically challenged but have difficulties understanding and applying mathematical concepts. This could be affecting how well these students perform in math class.

Muema, Mulwa, and Mailu (2018) conducted research in Kenya's Garissa County on the connection between teaching strategies and math students' achievement in the Dadaab Sub- County's public secondary schools. Shavelson, McDonwell, and Oakes (1987) created a conceptual model that served as the study's foundation. The study used a mixed-approach experimental research strategy for data gathering and analysis. Target population included form two pupils and all head teachers from the ten secondary schools in Dadaab Sub-County. There were 155 chosen responses in all. 30% of the students, all mathematics teachers, and five school principals made up the study sample. For the math instructors and principals, a purposeful sample was chosen. To select the student sample and then divide the students into the research groups, stratified

random sampling and simple random sampling were both utilized. The study included all of the principals and math teachers from each of the sampled schools on purpose.

Both qualitative and quantitative information about respondents was gathered through the use of achievement assessments, structured questionnaires, and interviewing protocols. Together with the quantitative data, qualitative data was thematically coded, quantized, and incorporated into the SPSS statistical tool for social science (SPSS), presented with the use of statistics tables, graphs, and charts. According to the study, there is a link between effective teaching strategies and students' mathematical achievement. This study did not examine certain teaching strategies and how they aided students in achieving high arithmetic performance. This study on teaching methods and students' arithmetic performance was particularly interested in how each method a math instructor employed affected the students' math performance.

ICT-based instruction was significantly more linked with student achievement than conventional methods of instruction. This suggested that utilizing ICTs in the classroom could enhance student performance. According to the study's recommendations, the government, through the ministry of education, should make sure that ICT resources are sufficient in schools so that both instructors and students can make use of them during the teaching and learning process. The ministry of education should set up seminars and other venues to inform teachers about the use of ICT in the classroom. This would guarantee that teachers embrace ICTs and often and appropriately use them in their classrooms. The findings of this study aided the researcher in determining the extent to which the Ministry of Education has implemented the usage of cutting-edge teaching techniques and teacher preparation programs to improve classroom instruction.

One of the most difficult aspects of teaching mathematics is devising instructional sequences that allow students to originate, develop and extend their informal and intuitive reasoning to more profound and formal modes of thinking, (Mutodi, 2016). Teachers must carefully analyze existent or informal knowledge of the students that can be used to create formal or conventional mathematics while designing such learning sequences. Quinnell and Carter (2012) propose that giving students opportunity to read, write, and verbalize symbols and explanations is a key element of mathematics learning. Students tend to underrate, if not completely dodge, verbalizing their thinking mathematically according to Duval, (2006). Students frequently have difficulty pronouncing symbols. Rubenstein & Thompson suggest reading mathematical expressions and problems aloud to identify misconceptions (2001).

Mathematics symbols ought to be approached with caution by teachers. Mathematical symbols must be written with extreme care, considering the size, position, and arrangement of the symbols (Rubenstein & Thompson, 2001). Symbolic, written, graphic, and oral language must all be linked and connected. Students are required to provide examples and counterexamples of expressions, compose symbolic statements related to diagrams, write and read symbolic statements, and provide examples and counterexamples of diagrams, according to Rubenstein and Thompson (2001). Learning the signs, symbols, and terminology of mathematics, according to Bossé and Faulconer (2008), is an important part of developing a learner's ability to be proficient in maths. This is better achieved in problem-solving settings where students get a chance to write, read and discuss their thoughts in a situation where the use of mathematical terminology becomes more natural. Students learn to clarify, develop, and consolidate their thoughts as they convey their ideas.

In mathematics, communication is defined as the capacity to express math concepts in a variety of forms and to connect those depictions according to Clement, (2004). According to the NCTM (2000), the guidelines for understanding and interpreting mathematics symbols are also not necessarily consistent with the English manner of expressing relationships. A mathematical language consists of a set of letters, symbols or words that all have unique interpretations that follow a set of rules and are used to transmit ideas. It's made up of words and symbols that symbolize items but aren't those objects themselves. Learners may face difficulties as a result of this.

Language and mathematical processes diverge well above level of symbolic processing, according to Matejko and Ansari (2016). Skill in one area does not imply competence in another. Differences in syntax are a result of this disparity. Language syntax and mathematical syntax are both characterized by the capacity to comprehend symbols. The two must be learned and taught. Excellent grammatical, writing, and reading skills don't always equate to good mathematical computation and problem-solving abilities. There is a correlation between having poor language skills and having poor math skills, which suggests that both require the ability to process symbols. Mathematical thinking is reflected in reading and interpreting mathematical symbolism as one would interpret English words.

At the secondary school level, word problem-solving is essential to teaching and learning mathematics; students' knowledge and mathematical skills are impacted by their ability to solve word problems, particularly when doing translational tasks (Burns, 2007). Students in secondary school are introduced to word problems at an early stage of their mathematics studies because of the general importance of word problem knowledge in mathematics.

Students frequently try to solve problems mechanically by cramming statements and methods, which leaves them disappointed. As a result, word translation to symbols is unquestionably one of the trickiest and most important steps in finding solutions to word issues (Esuong et al., 2019). This is due to the fact that learning the elements of mathematical language that allow students to translate words tends to conflict with how words and symbols are used in daily life, which children are more accustomed to in their immediate surroundings but outside of the context of mathematics. This makes it extremely difficult for pupils to comprehend the word-to-symbol translation, especially at the beginning of their mathematical language development. This is in line with Mayer (1987, as reported by Yared, 2003), who found that people tend to remember information that is congruent with their existing schemas when translating utterances into symbolic language. That is, when students attempt to interpret word problems, they often end up distorting the information in the issues by interpreting phrased assertions based only on symbols they have already encountered.

Furthermore, Yared (2003) claimed that the key to success in math problem-solving is the capacity to translate words into symbols and comprehend and value mathematics correctness, brevity, and logically mathematized expression. In other words, if learners are to appropriately use mathematical symbols in answering word problems, they must first instill the symbolism, precision, and brevity that have been age-old qualities of mathematics.

In a study on symbolic translation for kids exposed to English-spoken phrases, Bardillion (2004) discovered a direct correlation between students' proficiency in the symbolic translation of English words and their aptitude for solving mathematical problems as secondary school students. Students who frequently comprehend science and math mnemonics like BODMAS, MR NIGER D, and SOHCAHTOA perform

better when using and applying mathematical symbols. This is logically related to Yeo's (2009) claim that students find science classes like physics and chemistry challenging because they rely too heavily on symbolic notations, which are often pre-established constants used for scientific calculation. As a result, the majority of science-related disciplines are replete with symbols that must be correctly deciphered in order to perform any operation on them.

Similar findings were found by Cruz and Lapinid (2014) in their study titled "Students' Difficulties in Translating Worded Problems into Mathematical Symbols," which looked at the students' success and level of difficulty in this area. During the third quarter of the 2012–2013 academic year, twenty-one (20) item problem-solving test involving the four fundamental operations was administered to twenty-four (204) secondary school pupils. Scores on this test indicated how well they had translated worded issues, whereas analysis of their errors revealed how poorly they had translated worded problems. According to the results, 40% of the respondents performed less than satisfactorily while translating phrased difficulties. The respondents frequently had trouble translating stated problems due to carelessness, a lack of understanding, shifting values, and unfamiliar terms. Given these findings from the study, word issue challenges for students can be overcome by developing various student techniques and activities.

According to a related study by Aniano (2010) titled "Students' Word Problem Strategies," one element affecting students' ability to solve word problems was how difficult it was to translate phrases into symbols. This study focused on how well secondary school students could translate textual problems into mathematical symbols and the methods teachers may use to help pupils overcome their challenges. The study also showed that teachers' instructional tactics for word problems and their role in

helping students comprehend how to translate phrases into symbols had an impact on students' knowledge of symbolic interpretation and overall success in word problem-solving. Thus, word-to-word interpretation must be emphasized by teachers to help pupils comprehend the symbols that are related to each word in a given problem.

The authors of a study titled "Mathematics word problem solving through collaborative action research" (Vula and Berdynaj, 2011) used a different approach. The study used cooperative action research to assess word puzzle solving. A 30-item word problem-solving test with elementary school students was created and given. The assessment's results evaluated how well collaborative action research assisted students in understanding challenges with straightforward wording. According to the findings, there is a 70% chance that students working together in a classroom setting will come up with the right symbolic interpretation for every given word problem. This suggests that a collaborative classroom helps students comprehend and interpret symbols in mathematical word problems more quickly and simply.

Powell et al. (2012) also examined how well children with math difficulties (MDs) did on word problems and how they approached them. The effectiveness of a word-problem intervention was also evaluated in the study, and word-problem achievement between students with MDs who received the intervention ($n = 51$) and those who received word-problem instruction in a general education classroom ($n = 60$) was compared. The goal of the intervention, which took place over the course of 16 weeks, three times weekly, was to aid students in comprehending the schema and symbols utilized in word problems. Results showed that students with MDs who received the word-problem intervention did better than students with MDs who received word-problem training in general education classrooms. In order to better understand how students construct and resolve word problems, the study also examined the word-problem techniques of 30

randomly chosen study participants. In comparison to children who just received general education classroom word problem teaching, students who received intervention had more advanced word problem methods, particularly in symbolic interpretation. Findings suggested that children with MDs who are exposed to a rigorous mathematics language class emphasizing the symbol's identification, interpretation, and usage will perform better than students who received ordinary classroom word problem teaching. This is especially true in word problem interpretation.

All of the evidence suggests that learning mathematical language using symbols is essential for comprehending and interpreting word problems in the sciences and mathematics. Therefore, emphasis must be made on students' comprehension skills. Math's and other science-related topics use symbols. Additionally, teachers should make a concerted effort to translate each word, phrase, and sentence in the mathematics language teaching in symbolic form so that students can comprehend it, which will enhance their mathematical performance.

Although it appears to be one of the most difficult challenges for students, especially at the secondary school level, to translate verbal problems into straightforward mathematical equations. Since most students lose interest in mathematics due to their failure to comprehend its symbols, it is seen to be a significant barrier to learning mathematics and other science topics.

The impact of mathematical symbol education on students' academic progress is moderated by a number of environmental, sociocultural, and psychological factors, including gender, age, location, task difficulty, and self-esteem. The current study concentrated on the gender's moderating effect as a result. Gender is a social construct

that refers to the varied cultural attributes that are given to men and women. The word "gender" is used to refer to the link between masculinity and femininity as well as the emphasis on social (as opposed to biological) characteristics of women and men (Hyde et al., 1990). In this study, gender is taken into account in relation to potential discrepancies between boy and girl word problem accomplishment when taught via mathematics symbol instruction. For instance, earlier studies have demonstrated that females typically outperform boys in terms of overall school achievement, but that they underperform boys in terms of mathematics (Esuong & Edoho, 2018). This finding can be taken as a problem with girls and math. Boys are reportedly superior to girls in science and math (Aremu, 1999), while Georgius and McConell (2008) discovered that girls outperformed boys in various other courses. When Esuong et al. (2019) looked at how gender affects accomplishment, they discovered that male and female students typically perform differently in a range of academic subject areas. Traditional topics like math, science, and reading are prone to glaring gender inequalities in attainment (Owan, 2020). Male students typically exhibit greater motivation to perform better in the sciences and math, whereas female students excel in reading (Ayara et al., 2019). Sex is a role in students' success in school mathematics, according to Owan et al. (2019). On the general tendency, in Nigeria, they argue that male learners tend to achieve higher in mathematics than their female counterparts. The current study examined the impact of a mathematics symbols instructional technique on students' performance in word problems among senior secondary school students, which is contrary to the facts stated above and is evident. Additionally, it examines how gender variations in math symbol education affect students' performance in word problems.

2.3 Challenges Students Face with Mathematical Symbols and Their Impact on Performance

Difficulties in memorizing mathematical symbols in written form Learners struggle with formal symbols, a particular kind of mathematical language. Mathematics' unique written symbolism is the most difficult sort of language to master. Teachers must be aware of students' limitations in learning mathematics in order to build and develop learning settings that effectively enhance knowledge. Standard written symbols serve a crucial part in mathematics instruction, but learners may have difficulty deriving mathematical meanings from them. Learners extract meaning from symbols by connecting them to other types of representation (such as real things, pictures, and the spoken language) or by making links within symbols (Yetkin, 2003).

Learners may have difficulty understanding a written symbol, as stated by Yetkin (2003), if the referents do not accurately convey the mathematical meaning or if the relationship between the written symbol and the referent is not satisfactory. The context of the problem is what determines how mathematical symbols should be interpreted. They should be provided with materials that illustrate written mathematical symbols as well as information about the application of mathematical symbols in a variety of different scenarios. According to Bransford, Brown, and Cocking (1999), the best way to learn concepts is to experience them in a variety of contexts and to express them in a number of different ways.

In the United States, Rittle-Johnson & Alibali (2021) identified several challenges students face with mathematical symbols. Their study highlighted issues such as confusion between similar symbols and misunderstandings about their meanings. For example, students might struggle to differentiate between symbols like '+' and 'x' or misinterpret variables and operators within mathematical expressions. These

difficulties can lead to errors and hinder students' problem-solving abilities. The research underscores that these challenges are not trivial but significantly impact students' capacity to use symbols effectively in problem-solving. Addressing these difficulties necessitates targeted instructional strategies that provide clarity on the meanings and uses of mathematical symbols, as well as ample practice to reinforce correct symbol usage.

In Australia, Grootenboer & Hemmings (2022) explored how difficulties with symbolic notation affect students' performance and emotional well-being. Their findings reveal that students who struggle with symbolic notation often experience reduced confidence and increased frustration, which can negatively impact their mathematical success. For instance, students who have difficulty with symbols may become less willing to participate in class or shy away from complex problems, leading to diminished academic achievement. The researchers emphasized the need for targeted interventions to mitigate these issues. Such interventions could include additional support, differentiated instruction, and strategies designed to build students' confidence and alleviate frustration, thereby fostering better learning outcomes.

In Portugal, Azevedo et al., (2023) examined the role of conceptual understanding in overcoming difficulties with mathematical symbols. Their research found that students who lack a deep understanding of the concepts behind symbols are more likely to struggle with their application. For example, students with only a superficial grasp of what a variable represents may face challenges in solving equations or understanding functions. The study argues that without a robust conceptual foundation, students are prone to misconceptions and errors when using symbols, which can adversely affect their performance. Their study highlights the importance of integrating conceptual explanations with symbolic instruction. By helping students grasp the underlying

concepts and relationships represented by symbols, educators can more effectively address these challenges and improve students' overall performance in mathematics.

Learners are able to acquire a better understanding of the textual symbols by developing connections within the system. For instance, the number of units of any power of 10 can be represented by a numeral such as 3254. In other words, it is equivalent to three thousand, two hundred and fifty-four units, and it is also equivalent to three hundred twenty-five tens, thirty-two hundred, and three thousand. Adults may be able to recognize these patterns, but learners may not be able to do so (Whitebread, 2012). As a result, teachers need to be conscious of these challenges and create opportunities for students to notice patterns and connect them within the symbol system. Mathematical comprehension is a critical but challenging task to achieve. Recognizing learner challenges and their sources, as well as devising instructions to alleviate them, are critical stages toward reaching this goal.

Oral and written communications regarding mathematics concepts is not always acknowledged as a significant aspect of mathematics education because mathematics is often presented through symbols. Teachers must assist students in learning how to converse about mathematics (NCTM, 2000). The mathematics that students discuss should get more complicated and abstract as they advance through the grades. Learners' toolkits and communication methods, and the reasoning skills that drives their communication, should grow in sophistication. It is recommended by Hattie and Donohue (2016) that teachers develop classroom cultures that stimulate learning in order to help students develop effective communication skills that promote deeper learning. However, this recommendation is not sufficient on its own to ensure that students will have a deeper comprehension of the material. Non-English speakers may require additional assistance in order to understand mathematical lectures, but they are

still able to fully participate in classroom activities if those activities are run effectively (Ferreira, 2011). The ability to "assign symbols to represent objects or ideas, draw links between them, and work with them conceptually" is something that is unique to humans. This ability is referred to as "symbolic initiative."

He attributes the success of mathematics to this inherent human ability. Humans have symbolic initiative, which means they designate symbols to represent objects or ideas, establish links between them and also operate with them as if they were physical items.

Mathematical symbols are translated into spoken language in verbalization tasks. The surface structures utilized to transfer concepts are referred to as verbalization (K'Odhiambo & Gunga, 2010). According to Thompson and Rubenstein (2000), it is difficult for a student to register mathematics if he or she is not able to read mathematics aloud. . Reading serves as a bridge between knowledge and comprehension. Some symbols are difficult to speak because they require numerous words, while others can be expressed in a variety of ways. Depending on the situation, a symbol's verbalization can alter. When students are working on more sophisticated assignments, they may need to be exposed to verbalizations of common symbols (Maharaj, 2008). As a consequence of this, students are required to not only recognise the symbols, but also learn to link them to particular ideas, methods, and the language that is used to describe those concepts.

Mathematical communication is a technique that students must master. Learners must regularly engage in discourse and discussion about mathematics-related issues, as well as discover mathematical approaches. According to Siegel and Fonzi (1995), classrooms are portrayed as input/output situations with little verbal exchange between students and teachers. Teachers must be able to relinquish some control over their

classroom's instructional environment and allow students to be little more than passive recipients of the contents they need to master. One technique to engage learners in formative assessment is to have them discuss about mathematical topics. Another advantage is that students may realize what they don't comprehend on their own. This allows people to fine-tune their reasoning, which may strengthen their metacognitive talents over time. Teaching through conversation promotes strong learning by improving memory, reasoning, language development, and social skills as advanced by Coe, Aloisi, Higgins and Major, (2014).

Correct terminology and language are also important aspects in verbalizing mathematics. How can students comprehend mathematics if they do not communicate the mathematical language? Learners and teachers, according to Mercer and Sams (2006), need to communicate and reason using functional terminology. Knowing how to utilize math language effectively in everyday conversation is an important part of mastering the subject. Teachers must understand that acquiring vocabulary entails more than memorizing definitions. Providing students' vocabulary with definitions or asking them to find definitions isn't enough to help them understand the words' meaning or read and use them correctly.

Kenney, Hancewicz, Heuer, Metsisto, and Tuttle agree (2005). In the classroom, teachers and students should use the word correctly. This incorporation will assist learners in understanding the terminology by making it a regular part of their spoken language. Many students speak math at school but not at home. Mathematics isn't a "first" language because it's not spoken (Kenney, Hancewicz, Heuer, Metsisto & Tuttle, 2005). To learn the material, students must be active participants, not passive observers. They must be engaged students. Although mathematics is frequently communicated

using symbols, spoken and written communication regarding mathematical ideas is often not considered as a critical component of mathematics education.

According to O'Connell and Croskey (2007), learners do not naturally converse about mathematics and therefore require assistance from their teachers in order to learn how to do so. Math that students convey becomes more sophisticated and abstract as they go through the grades. Learners' toolkits and modes of communication, as well as the fact that English is the language of teaching at the secondary schools in South Africa (Mncwango, 2012). However, mathematics is viewed of as a topic having universally accepted terminology and a symbol system with condensed meaning everywhere in the globe (Wasike, 2006). The mathematical thinking that underpins their communication has to improve. Learners require a lot of help. Learners whose first language is not English often require more help in able to profit from information exchange mathematics classes, according to Eisenchlas, Schalley, and Guillemin (2013), but they can fully participate provided classroom activities are designed effectively.

The policy on language in these symbols and terminology are unfamiliar and, in some cases, contradict standard English interpretations, particularly in the field of statistics.

Learners must master mathematical symbols and concepts in order to communicate mathematically with others. Learners learn to clarify, develop, and solidify their thinking as they attempt to convey and enhance their understanding of mathematics through communicating their ideas (NCTM, 2000). According to Mulwa (2014), communicating in mathematics requires meaning negotiation and sharing. Symbols are used to convey the meanings. Learners' mathematics literature offers a common, natural framework for mathematical communication. Mathematical discussion not only

improves learners' verbal language ability, but it also improves their mathematical thinking and communication ability (Moyer, 2000).

Mathematical communication refines, discusses, and modifies ideas. The communication procedure also aids in the development of ideas' meaning and permanence, as well as their dissemination. Learners learn to be precise and compelling when they are asked to think and deliberate regarding mathematics and to express the outcomes of their thoughts to others whether written or orally. Learners can build their own understanding by listening to other people's explanations. Mathematical concepts discussed from multiple angles help participants think critically and make connections. Learners who participate in debates in which they defend solutions, especially in the face of controversy, will gain a stronger understanding of mathematics (Smith, Silver & Stein, 2005). This type of assignment helps students develop a mathematical language and understand its importance. Learners who are given opportunity, encouragement, and assistance in mathematics classes for writing, speaking, reading, and listening reap two benefits: the students learn to communicate mathematically and they also communicate to learn mathematics (Falk-Ross & Evans, 2014). How teachers and students verbalise math is poorly researched. Research on learners' verbal and symbolic math language management often focuses on their understanding and responses to mathematical books.

Reading comprehension issues in mathematics are common among students. Learning is necessary in order to communicate in mathematics (Simonson & Gouvea, 2003). Reading, recognising, and comprehending symbols are required skills for every aspect of mathematics (Bardinia & Pierce, 2015). Reading is more than just pronouncing words and assigning meaning to symbols. Reading mathematical expressions involves more than just manipulating numbers. Reading a math book requires an understanding

of symbols for grouping information and determining relationships. Any strategy for improving math reading must place an emphasis on comprehension in order to make the most of learners' subject-matter expertise.

Reading mathematical text requires a reading strategy, which can be thought of as a collection of reading tactics that are used to get the most out of the material. Reading mathematics requires you to cross-reference, reflect, skim, pause, revisit, and reread the material. In their writing, mathematicians place a premium on brevity and precision (Shepherd, Selden & Selden, 2009). The majority of mathematics textbooks used in Kenyan secondary schools include an exposition of ideas and methods, definitions of key phrases and terminology, scientific theories relating to the topic as well as less formal mathematical presumptions, illustration, figures, tables, worked illustrations, and activities at the end of a sub-topic or concept, as well as a summative exercise for practice at the end of the topic.

Many perplexing symbols that are ideographs instead of letters can be found in mathematics textbooks. A graphic symbol which expresses an idea or notion is referred to as an ideograph. Some ideograms can only be deciphered by prior knowledge of convention; others, known as pictograms, transmit meaning through a graphic likeness to a physical thing. Learners cannot "spell or sound out" the meaning of such complexity while reading. Reading a math text involves a variety of cognitive processes, including analysis, the transmission of meaning from a symbol system, and literal and inferential thinking (Randi, Newman & Grigorenko, 2010). Reading math can be challenging. Some mathematical terms, such as "inverse" in arithmetic and "inverse" in functions, have many meanings depending on the discipline of mathematics. Many students struggle to understand the symbolic aspect of algebra and variables, as per Tall and Gray (2001). According to Anthony and Walshaw (2009),

offering opportunities for learners of all ages to talk about, read about, and write about maths helps them develop concepts faster. When it comes to concept formation, verbal engagement among classmates is a huge help (Dennen, 2004). However, few students are given the opportunity to express mathematical concepts and symbols verbally. According to Pillay and Adler (2015), instructor presentations and solo silent work usually dominate school mathematics learning. In today's classrooms, group discussions are becoming less common. Mistakes and misinterpretations are an inevitable and valuable part of learning. Communicating and justifying one's ideas helps develop a thorough understanding of them.

The capacity to read maths is a crucial and essential skill for students to gain. Students who are able to read and also grasp mathematical writing and language will have an easier time understanding and succeeding in arithmetic (Buchanan, 2007). Weinberg and Wiesner (2011) explored transactional reading theory-based math instruction. They explained why math text is harder to read and what skills are needed to understand it. The capacity of the student to interpret mathematical symbols as well as the particular and distinctive language employed in technical mathematics literature is critical to successful reading.

Students who are able to read and comprehend mathematical material have an advantage in their day-to-day schoolwork, in examinations, and in other types of tests as well, such as college entrance exams. Teachers must instill in students the ability to read and comprehend mathematics as a language. One way to accomplish this is to approach mathematics as a foreign language that must be taught, learnt, practiced, and comprehended. Reading and comprehending mathematical writing is a talent that must be exercised and learnt rather than an inherent ability. When reading mathematics texts, Adams (2003) identified several of the skills that students need. In mathematics classes,

he claims, reading is frequently ignored or undervalued. Reading maths is a multifaceted job since it requires the reader to develop mathematical understanding and comprehension with ease and skill by reading numerals and symbols in addition to words. Many students struggle with math because they can't focus on the symbols while trying to read the mathematical concepts. To help students read math, teach them how to read and have them practise often (Buchanan, 2007). Mathematical literacy must be taught. Math can be taught, learned, practised, and understood as a second language. Reading mathematical writing is a learned skill, not an innate one. Mathematical reading and writing seem mutually beneficial.

Mastering one skill makes mastering another easier, and vice versa (Rosa & Orey, 2010). Because mathematical writing differs from fiction and even most genres of nonfiction, reading mathematics differs from reading a novel. The writing in mathematics is both concise and dense. New concepts are built logically on top of those that have already been introduced. The reader is challenged by the reader's specialized terminology, numerous symbols, and elaborate pictures. Shepherd, Selden, and Selden (2009) summarised students' math textbook reading difficulties. Students have inadequate prior knowledge due to poorly developed concept ideas; (2) Students struggle with the syntax and accuracy of mathematical descriptions, examples, and absence of exposition in arithmetical writing; and (3) Students ground abstract math concepts in concrete objects or actions while reading.

Inability to generate proper symbols for a particular mathematical problem is referred to as writing difficulties. Phillips (2008) said that creating sentences aids learners in writing correct symbolic expressions. Many students, on the other hand, find it difficult to express themselves mathematically in writing. The majority of students think this skill isn't necessary. The style of mathematical writing, on the other hand, is distinct.

Clarity and precision are at the heart of good mathematics writing. Learners can more easily connect meanings to symbols and derive meanings from symbolic expressions if they regularly deconstruct the meanings of symbolic statements. When mathematics teachers are intentionally and consistently responsive to students' meaningful use of symbols, a new culture arises in their classrooms. Learners will connect mathematical principles to the symbols used to depict them. Learners will gain symbol sense and become stronger symbolic reasoners as a result of this process. Math symbols obstruct many students' mathematical progress. To avoid symbol misunderstandings, students should become familiar with symbols ahead of time and possibly write out what they signify in words. Exponents can include "multiply by itself." Learners can then understand and analyse math symbols without being confused by the language.

2.4 Discussion in the Classroom

Another key part of mathematics education is equipping students with the ability to convey what they know or believe. Class discussion and team work are other recommended techniques to enable all learners to communicate (Ololube, 2015). It has long been assumed that students learn better when they are compelled to explain or teach an idea to the rest of the classmates as compounded by Kihlstrom, (2011). This entails the ability to express whatever they've learned. As a result, teachers must encourage students to verbalize their own knowledge in order for them to learn more effectively. Listening to explanations from their classmates is equally beneficial to learners on the listening end. When students listen to one another, they often gain from hearing concepts articulated from many perspectives and in ways that are more similar to their own. When students listen well, they come up with questions that help them think more deeply. The process of associating suitable interpretations to mathematical symbols could be hampered by a heavy emphasis on instrumental learning in the

classroom (Goldstone, 2012). Pseudo- conceptions are often more likely to emerge in such a learning setting since the area of research is not cognitively engaged. When a student is taught to comprehend a mathematical item, such as an equation, through its attributes, these pseudo-conceptions can be exceedingly resistant to alter and can even operate as cognitive hurdles.

2.5 Timeous Introduction of Symbolism

In response to learners' difficulties, numerous scholars (Radford, 2006; Drews, 2007; Mduli, 2014; Boorman, 2015) advocate for timely problem-solving instruction to provide a range of meanings to mathematics symbolism. Why haven't these guidelines been adhered to at all times? A recurring assumption in educational thinking, according to Moodley (2016), is that knowledge should be gained first, while implementations for critical thinking and problem solution must come later. The formation of connections among mathematics symbols and problems, on the other hand, is a difficult process that cannot be condensed to a straightforward translation.

Learners should comprehend symbols by establishing links inside the system, according to Doig, McCrae, and Rowe (2003). Teachers of mathematics must be aware of the given obstacles and give opportunity for students to find links within the symbols systems. As proposed by Worthington & Carruthers, (2003), helping students make connections between informal math and school math is crucial

Designing learning settings that encourage students to connect their formal and informal mathematics expertise and using the most relevant representation for the problem can help students study written symbols. Wolska, Daroczy, Nuerk and Meurers (2015) suggest that reading is an imaginative and cognitive procedure which necessitates a good understanding of the interactions of several distinct capabilities.

Language is less precise than mathematical symbols. Numerous interpretations and ambiguity aren't usually regarded part of the mathematics register or computations until they're used in statistical inference. There's a risk of focusing on symbols before they're ready since symbols remain abstract and do not have meaning. Learners must be able to comprehend the symbols they read and write. Starting with symbolism's abstract nature is nearly always a recipe for disaster. If instruction starts with semi-concrete and concrete situations which may be linked to substantial verbal understanding, symbols become meaningful.

A strategy that can assist students understand seemingly puzzling symbolism should be to offer them past context. A tale about the evolution of Leibniz notation, for example, could aid learners' comprehension of integral notation. Another technique to clear up ambiguity is to remind students that symbols possess multiple interpretations under varied circumstances and also that another symbology of a similar concept exists frequently. Learners' understanding can be improved by breaking down complex symbols piece by piece. Breaking the expression down into smaller, easier-to-understand reference units is part of this. Students could very easily connect meanings to symbols as well as derive meaning from symbolic statements if they routinely unpack symbolic statements' meanings. When teachers are intentionally and consistently responsive to learners' appropriate use of symbols, a new culture arises in their classrooms.

Learners will be able to relate between mathematical concepts and the symbols that express them. Students will improve symbolic perception therefore becoming stronger reasoners of symbolism as a result of this process.

2.6 Creating Connections between Written and Manipulated Mathematics Symbols

Handling of actual materials is insufficient on its own to enable students to comprehend abstract, symbol representations of mathematics concepts (Blair, Blair & Schwartz, 2012). As students progress through school, it is crucial that they comprehend these symbolic representations (Uttal, O'Doherty, Newland, Hand, & DeLoache, 2009). Although handling and using real things is vital for understanding mathematical concepts, especially in the initial years of schooling, students also have to be in a position to link real and symbolic representation. As a result, amongst the most crucial responsibilities of math's instructors, one is to assist scholars in comprehending and manipulating symbolic representations.

To create strong and persistent connections, learners require repeated encounters and a variety of concrete resources. Teachers frequently add to learners' challenges during this level of education by trying to ask them to connect photographed clusters to numeric tasks even before they've had enough practice relating different physical representations to different forms of connecting mathematical symbols around each other, as well as the various aspects we describe such objects through words. Real items are significantly more realistic teaching tools than photographic representations since they can be held, moved and physically gathered and separated.

Because images are semi-abstract symbols, they may distort the delicate links that are being made between the new mathematical language and the existing concepts if they are introduced too early. Paul and Marshall (2008) also point out that organized tangible resources can be advantageous during fundamental formulation phase of math concepts throughout school stages. The obscurity of textual mathematical symbols can be overcome by using concrete objects. According to research, students who use concrete

objects acquire more exact and thorough mental representations, are more motivated and on-task, have a better knowledge of mathematical concepts, and can apply such concepts to real-life circumstances (Hiebert & Grouws, 2007).

The idea of dual representation, according to DeLoache (2004), helps provide light on this basic dilemma. This concept's core tenet holds that symbolic items possess a double structure that is they both represent entities in and of themselves and are also representation of another thing. For effective utilization of symbolic item, someone has to concentrate at whatever a sign is supposed to symbolize rather than upon the external features. Symbolism can often be hard to explain to students that are unfamiliar with the concepts they represent (Ball, Thames & Phelps, 2008). However, for students who have not yet mastered the symbols, the concept may be challenging to convey. This scenario poses a problem for teachers who are trying to figure out ways to teach symbols and concepts in a sequential.

Hiebert (1988) provides a hypothesis to understand students' "excessively mechanized behavior" in a classroom. The hypothesis is relies on the way students gain proficiency in handling mathematical documented symbol system. He also proposes a set of cognitive procedures that, when combined, result in written mathematical symbol competence. Five primary mechanisms were recognized by him: (i) linking each symbol to its referent; (ii) Creating procedures for symbol manipulation; (iii) elaborating symbol manipulation procedures; (iv) routinizing symbol manipulation procedures; and (v) using rules and symbols as referents to come up with quite abstract symbol structures.

Written marks in textbooks reflect math quantities or operations on quantities. Pupils have to be acquainted with the measurements and operations on the measurements, as

well as the written elements which are utilized to represent the numbers as well as the operations. Next they establish a link among the numbers written down and the operations that are represented by them. Many students' informal knowledge includes familiarity with amounts that can be utilized as referents. Learners frequently engage in tasks that use materials and concepts in order to determine how many, how much, and when they should do something. These ordinary experiences provide quantity knowledge and acts on amounts, which can serve as the primary referents for mathematical symbols written down (Nunes, Bryant & Watson, 2007). As learners create links between particular symbols and familiar referents, their competency with written symbols grows. Individual symbol meanings emerge as associations are made among the written markings on a sheet together with numbers or events they symbolize (Pape and Tchoshanov, 2001). Creating mental bridging connecting referents with symbols then traversing over numerous occasions is part of this process.

Connections between numerical symbols and amounts are important because they give mental pathways from the symbol all the way to the referent. If the problem is presented to learners as written symbols, they are able to remember mind picture of associated objects thus deliberate closely about the quantities to address this situation (as in ordinary classroom lesson). The quantities function like "conceptual elements" as compounded by Greeno, (1983), or cognitive entities where problem-solution techniques use as justifications. Such conceptualizations help unfamiliar students solve problems. Creating procedures for symbol manipulation: The advancement of symbol procedures is the other cognitive process needed to continue developing competence with symbols. By changing the referents of particular symbols, monitoring the outcome and comparing the operation on referents with the operation on symbols, the processes are created. Routinizing symbol manipulation procedures: If the methods are

thoroughly practiced, the symbol system can be employed more effectively. When procedures are repeated frequently enough, they become automatic, requiring little forethought, and the user realizes maximum efficiency.

Using rules and symbols as referents to come up with quite abstract symbol structure: Symbolic structures advance by improving on each other as put by Goldin and Kaput, (1987). As more abstract concepts are met as well as the manner in which they depend upon the previous basic patterns are understood, learners' proficiency with symbols continues to increase. The transmission of meaning straight as from its initial regulations and symbols through to subsequent structures is one approach that subsequent systems might build on previous ones. Another way is by identification of a relationship between two separate symbols systems is the second method. Students may transmit interpretations from an acquainted symbol framework to the novel and a bit abstract when they have ascertained significance for recognizable symbols (the two initial procedures have been fully engrossed) also recognize a navigation around the frameworks, allowing the known rules and symbols to act as referents for the latest framework.

2.7 Mathematical Reading Instruction

Math is likely the most difficult of all the subject-area literature that secondary school students read (Barton, Heidema & Jordan, 2002). When it comes to reading arithmetic texts, students have problems. Math is a language in which problems are translated from written text to algebraic form using words and symbols. Mathematics, according to Adams (2003), is a language made up of words, digits, and symbols that are sometimes interconnected and interdependent and other times disconnected and autonomous. Adams (2003) says that learners' math skills are hindered by their inability to focus on symbols when interpreting math language. Textbooks are frequently written utilizing

symbols and diagrams in a simple manner. One of the primary issues is the intellectual density of mathematical text. According to Metsisto (2005), mathematics texts have the most concepts per line, phrase, and paragraph. Reading math requires specialised reading skills that students may not have developed elsewhere. Learners must decode scientific and mathematical symbols, signs, pictures, and text passages. Learners must read and evaluate information presented in unfamiliar ways, such as right-to-left (number lines), top-to-bottom (tables), or diagonally (graphs).

Learners must also interpret text differently than in other disciplines. Reading limits of functions, for example, might be difficult for certain students, for instance: $\lim_{h \rightarrow 0} (3x + 2h)$ is read as the limit of $3x + 2h$ as h approaches zero or the limit of $3x + 2h$ as h approaches zero. Given these difficulties, it's understandable that educators might wonder, "How can teachers assist students in reading and studying mathematics texts?" Burton, Heidema, and Jordan (2002) suggest using reading to help students activate past content knowledge, understand vocabulary, and fully comprehend unfamiliar text styles. Vacca & Vacca (2005) say a learner's previous knowledge is the most important resource in math. To make sense of new material, each learner actively relies on existing knowledge and experience. Learners will benefit from and retain what they read if they bring more symbol knowledge and abilities to the text. Activating prior knowledge helps students create logical connections, develop inferences, and absorb new information.

During instruction, the capacity to read and write, and verbalize mathematical words is frequently disregarded. These capabilities are required for students to comprehend and communicate in mathematical discussions.

Diagramming can help you speak, read, and write math. Rubenstein and Thompson (2000) say diagramming helps students connect mathematical vocabularies. Learners have battled with mathematics throughout history, from reading to writing to verbalizing. Furthermore, teachers should keep in mind that there is no all-encompassing list of tactics. There are so many possibilities. Students who can't read, write, or verbalise math terminology and ideas will struggle to learn math. Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) in America require students to communicate mathematically. They proposed that understanding the signs, symbols, and concepts of mathematics aids in the development of a learner's ability to utilize math. This is better achieved in problem-solving scenarios when learners have the chance to write, read and discuss ideas in a setting where the use of mathematical language becomes natural. Learners learn to clarify, develop, and consolidate their thoughts as they convey their ideas.

Callan (2004) later noted that few math classes fully integrate reading into instruction. Borasi and Siegel suggest using transactional reading to learn math (2005). These tactics engage readers in active meaning-making by inspiring reflective thought from equivocation. Additionally, Duke and Pearson (2008) argued that how learners read, and not just what they read, might affect their education.

2.8 Scaffolding

Advocates of the constructive approach claim that learning takes place when people are challenged to go beyond their current abilities and create new ones (Newby and Ertmer, 2013). As a result, learners require additional assistance from the teacher, peers, experts, artifacts, or tools in order to develop knowledge. Scaffolding is the term for the teacher's guidance to the students. Gibbons and Hammond (2005). Scaffolding should make students more independent. Teachers can use scaffolding to improve

students' knowledge by clarifying doubts, inviting responses, focusing on the task, and reinforcing key information. The teacher provides early instructional support (scaffolding) to help students develop new skills. Scaffolding describes the modern constructivist learning paradigm. Student learning requires scaffolding. Learners need scaffolding when they reach a certain developmental stage, defined by indicators in certain areas. Bassiri (2012) defines scaffolding as supported learning (assisted learning).

Memory, concentration, and symbol reasoning are examples of higher mental functions, according to Vygotsky (1986). These functions require support. The concept of scaffolding is predicated on the notion that students need access to teacher-learner, learner-learner, and learner- teaching materials in order to be able to construct new knowledge based on what they already know. Providing students with the opportunity to solve mathematical problems using symbols and then having a discussion about the concept may also improve students' math learning.

According to Hammond and Gibbons, (2009) scaffolding is an instructional strategy that inspires students to take responsibility for their own education. To define the difference between what a student can achieve individually and what they can be able to do with assistance, Vygotsky (1986) invented the term "zone of proximal development." Teachers must provide lots of support when required while also guaranteeing that learners are sufficiently pushed to progress.

2.9 Learning Theories in Mathematics Teaching Methods

According to the findings of research, the vast majority of math educators and aspiring educators have firm beliefs regarding the roles of students and teachers, methods of instruction, students' mathematical knowledge, how students learn, and the objectives

of schools (Thompson, 1992). The majority of beliefs held by professors can be traced back to their training. These perspectives on knowledge, learning, and instruction are taken for granted in the majority of conventional educational settings. Understanding students' learning, experience, reasoning, and logical capabilities is essential for math teachers who want to be successful in the classroom. They can use this information to better plan their math instruction. At every academic level, the instructors concluded that learning and teaching mathematics is an ongoing process that requires students to develop a comprehensive understanding of mathematical concepts and procedures. These teachers should encourage students to investigate mathematical challenges and think critically about how to solve them as well as problems that have a longer-term impact. The three approaches of behaviourism, constructivism, and cognitivism will be discussed after this.

2.9.1 Behaviorism

Watson (1996) and Skinner (1972) were the two key pioneers of behaviorist learning theories. Skinner believed that habits are the result of operant learning experiences, whereas Watson believed that human behaviour is the result of particular stimuli and responses (Shaffer, 2000). According to Kimble (1961, page 6), learning is defined as a "permanent change in the behavioural potentiality." Kimble places an emphasis on the following three characteristics of learners. Learning can be seen in changed behaviours. Second, the change will remain for some time. Third, there is no correlation between learning and changes in behaviour (Hergenhahn & Olson, 2005).

The use of rewards and punishments in the classroom is effective. They say that incentives help people learn better. Teaching based on the behaviourist philosophy places an emphasis on shaping behaviour through repeated activities. They establish objectives for both students and teachers (Hergenhahn & Olson, 2005). The prior

mathematical material and assignments are reviewed by the instructor, who then moves on to demonstrate simple problem-solving techniques and assigns seatwork consisting of copying the instructor's presentation (Stonewater, 2005). This method of instruction emphasises the role of the instructor as a knowledge transmitter (also known as "teaching by telling") (Hackman, 2004). The most prevalent technique of mathematics teaching using behaviorist theory is teacher-centered, with lecture being the most popular method.

2.9.2 Cognitivism

Cognitive method is another important theory. The first psychologist to study cognitive development was Piaget (1936). Cognitive development is the reorganisation of mental processes due to biological and environmental factors. Cognitive learning theory bases learning on how people interpret stimuli (Ormord, 1995). Benjamin Bloom developed a taxonomy for cognitive skills in 1956, including knowledge, comprehension, application, analysis, synthesis, and evaluation, which teachers should help students develop. Anderson and Krathwohl (2001) modified the six steps as Remembering, Understanding, Applying, Analyzing, Evaluating, and Creating (Wilson, 2013). Behavioral analyses of instruction are often insufficient to explain teaching's effects on learning, says a cognitive approach. Educational psychology uses cognitive and behavioural strategies. This approach in math education focuses on problem-solving.

2.9.3 Constructivism

Learners take the lead in the constructivist method, which places the emphasis on their own education. Constructivism advocates that students should not have their education handed to them. Children should be encouraged by their educators to be curious, to learn new things, to analyse what they find, and to think critically (Eby, Herrel & Jordan, 2005). Under the modern constructivist approach, children learn and

comprehend jointly. Learners are encouraged to actively interpret data and construct knowledge through the use of constructivism (Woolfolk, 2008). Constructivists believe that students should be responsible for their own interpretation of evidence. Students are actively encouraged to reflect on the effectiveness of their educational experiences by constructivist teachers. Teachers who use the constructivist approach encourage "expert learners. Theorists such as Jean Piaget, Maria Montessori, and Lev Vygotsky, as well as educational movements, inquiry or discovery learning, and open education, all made significant contributions to constructivism (Gagnon & Collay, 2001). Because constructivism places an emphasis on students developing their own interpretations of evidence and submitting them for review, it is necessary for students of mathematics to develop their own understanding of each and every mathematical principle. Educating students does not consist of lecturing, explaining, or passing on mathematical knowledge; rather, it entails putting them in situations in which they are encouraged to construct mental models. Constructivism as opposed to the role of the teacher as lecturer (Hanley, 1994).

Math is taught, according to constructivists, by having students engage in mental and physical activities. Learning, in the view of constructivists, is a social process that takes place through conversation and discussion (Hanley, 1994). This approach moves away from the traditional student-centered practices that have been used in education and gives both teachers and students more authority to rethink the methods used in education (Sawada et al., 2002). Hanley (1994) provides in-depth instructions on how to put constructivist teaching into practise. This method requires instructors to make use of the questions and ideas contributed by students, to collaborate on and encourage alternative sources of information, to encourage students to challenge one another's conceptualization and ideas, and to encourage students to analyse themselves.

2.10 Research Gap

According to the literature analysis, the majority of experts have identified elements that influence examination success of schools in advanced countries. Teachers' academic and professional training, teaching techniques, student-teacher attitude, and teacher experience are examples of such elements. Learning mathematical vocabulary is a crucial part of understanding mathematical language and symbols. Learning, thinking, interpreting, and conveying mathematics all need the use of mathematical symbols and language. This research study was meant to evaluate the influence of mathematical symbols on secondary school students' performance in mathematics in Koibatek sub-county, Baringo County, Kenya.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter covers research design, target population, sampling, instrument validity, data collection, and analysis.

3.2 Research Design

A research design is a set of parameters for data collection and analysis that strikes an appropriate balance between the two goals of the study. It is a structure for conducting research. According to Kothari (2004), it acts as a compass for the collection, measurement, and examination of data. For this study, a descriptive survey research design utilizing mixed method approach was employed to obtain data in an attempt to address the research questions. This design was chosen because it is the most cost-effective in terms of gathering data about the characteristics of a large population. A survey study further allows the researcher to obtain insight by researching many entities in a population which can have broader implications, while still determining and reporting the current state of affairs.

3.3 Study Area

The study was conducted in Koibatek Sub-County, Baringo County, Kenya, focusing on Form 3 students. According to records obtained from the Sub-County Education Officer (SCEO, 2019), Koibatek has a population of 2,800 Form Three learners. Koibatek was specifically chosen because of its unique demographic and educational environment, and there was a gap in research on the influence of mathematical symbols on student performance in this region.

While no similar study had been conducted in Koibatek Sub-County, studies in other regions have addressed related topics. For instance, research conducted in other counties such as Nairobi and Nakuru has highlighted the challenges students face in understanding mathematical symbols and their impact on performance in mathematics (Wenno, 2015; Njoroge, 2003). These studies generally found that students who struggle with interpreting mathematical symbols tend to underperform in national mathematics exams. However, the results also varied based on the teaching methodologies and educational resources available in those regions. Therefore, it was necessary to conduct this study in Koibatek Sub-County to understand how these factors specifically influence learner performance in mathematics in this area.

3.4 Target Population and Sample Size

3.4.1 Target Population

The target population refers to the entire group of individuals or objects to which the researcher aims to generalize the findings of the study (Pentz, 2014). In this research, the target population included both learners and teachers in Koibatek Sub-County. Specifically, the study targeted 2,800 Form Three learners, comprising 1,461 girls and 1,339 boys from 36 secondary schools in the sub-county. Out of these, 35 were public schools, and 1 was a private school. Form Three students were selected because they had studied mathematics for at least two years, giving them a fair understanding of the subject, and making them suitable candidates for the study.

In addition to learners, 36 mathematics teachers from the chosen schools were also part of the target population. Since the teachers play a critical role in teaching mathematical symbols and influencing student performance, it is important to include them in the study population.

3.4.2 Sample Size

In the target population section, the study included 36 secondary schools (35 public and 1 private) in Koibatek Sub-County. However, for practical reasons and to ensure manageability, 25 out of the 36 schools were selected to participate in the study. The selection of these 25 schools was conducted using a systematic random sampling approach to ensure that the sample was representative of the broader population. This approach allowed for a manageable yet statistically significant sample size, facilitating a more focused and detailed analysis of the impact of mathematical symbols on student performance.

The sample size of the learners for the study was obtained using Yamane Formula 1970.

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n= optimum sample

N = Number of students

e= probability of error (i.e, the desired precision, which is 0.05 for 95% confidence level).

Applying the formula this sample size will be calculated as follows:

$$n = \frac{2800}{1 + 2800(0.05)^2} = 350$$

3.5 Sampling Techniques

The process of selecting members of a research group in such a way that they are representative of the overall population is known as sampling (Mugenda & Mugenda, 2003). The zone schools and the Form three students were selected using a system of straightforward random sampling. According to Mugenda (2009), using purposeful

sampling enables researchers to select examples that contain pertinent research data. Because of this, cases that are helpful or essential are selected by hand (Orodho, 2009). Simple random sampling was used in a way that the researcher cut small pieces of paper in which either the words YES or NO were written on them and one teacher from every school was given a chance to pick just one piece. The ones who picked pieces of paper written YES participated in the research by filling the questionnaire while the ones who picked written NO did not participate. 25 schools participated in the study from each of the 25 schools based on their average performance of the term. The reason the researcher went for a YES and a NO was to ensure that biasness was avoided at all cost and that the picking of students and schools to participate in the interview was as fair as possible. The goal of sampling was to create a representative group that would allow the researcher to learn more about a population. The study utilizes a series of samples drawn from the target group. The Yamane formula was used to calculate 350 students as the sample size.

The sample size was 350 learners selected following Yamane's (1967:886) formula;

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e represents the level of precision or the margin of error which in this case is equal to 0.05. Using the population of $N = 2800$, we obtained a sample size of $n = 350$ learners.

3.6 Research Instruments

This involves the techniques for data gathering phase of the work. Interviews and questionnaires were employed to collect data in order to achieve the study's objectives.

3.6.1 Questionnaires

Questionnaires were given to the sampled students. Questionnaires were used because they could be distributed to a large number of people at once in a short amount of time. It was therefore less expensive particularly in terms of time spent collecting the data. The researcher first informed students why the research was being conducted for the students to be aware of what they were expected to do and what would be done with the information they submitted. The questionnaire delivered by the researcher was a self-completion of paper questionnaire by the students. Using the instrument made the respondent to feel that they could remain anonymous and thus were likely to express their opinions freely. There were open-ended questionnaires where the respondent created their own answers and closed-ended questionnaires which limited what respondent provided.

3.6.2 Interview Guide

The researcher conducted interviews using carefully designed items and questions that elicited information on the teachers' experiences, perspectives, reflections, and symbol perceptions. Teachers from the different schools whose students were chosen to take part in the surveys served as interview participants. The approach was then used to generate qualitative data in explaining the phenomenon under study, which were the influences that mathematical symbols had on mathematics performance. All the teachers of mathematics in the schools then participated in the discussion at the same time. The teachers were assembled in a conducive location after the researcher obtained their consent. The researcher already had designed a focus group discussion guide which helped her in the discussion. After the discussion, the researcher transcribed the data into qualitative information, for example, when 10 members were involved in the

study and if 7 affirmed that symbols in mathematics influence the performance in mathematics, then

$$\frac{7}{10} \times 100 = 70\% \text{ is the figure the researcher will report}$$

The researcher opted for focus group discussion for teachers since the method added more credibility and originality to the activity because it was the teachers themselves that informed the researcher. This was because teachers had first-hand information on what the influence of symbols are on the performance of mathematics of their students.

3.7 Research Instruments' Validity and Reliability

3.7.1 The Research instruments' Validity

Validity is a critical aspect of research that assesses whether a research instrument effectively measures what it is intended to measure. In other words, it determines whether the tool accurately captures the constructs it is designed to evaluate and whether the findings derived from the instrument can be interpreted as reflective of those constructs. Validity encompasses various types, including construct validity and content validity, both of which are essential for ensuring that the instrument provides meaningful and accurate data related to the study's objectives (Creswell, 2014).

To ensure the validity of the research instruments, several steps were undertaken. Construct validity was addressed by aligning the instruments with established literature and frameworks. Key elements from the works of Rukangu (2000), Njoroge (2003), and the Kenya National Examinations Council (KNEC) reports (2008, 2009, & 2010) were incorporated into the design of the instruments. This alignment ensured that the instruments measured the theoretical constructs related to mathematical symbols and student performance effectively (Mertens, 2015). Content validity was also a focus, achieved through a thorough review of the instrument's content to ensure that all

relevant aspects of the constructs were covered. This review process ensured that the questions were comprehensive and representative of the topics under investigation (Patton, 2015).

3.7.2 Reliability of the Research instrument

A research instrument's reliability is defined as the degree to which it produces consistent outcomes or data after multiple trials as per Mugenda & Mugenda, (2003). Using a test–retest procedure, the researcher evaluated the data gathering instruments' reliability. The questionnaires were given to 34 participants from a school that wasn't included in the final analysis. On two different dates, the respondents were provided with an identical test. After that, the two scores were compared. Pearson's product moment correlation was used to calculate the reliability (r). When the coefficient of stability is 1, the scores of each respondent are perfectly connected. That is, on both times, each respondent rated the same value. A correlation coefficient of 0 shows that perhaps the respondents' score on the two tests are completely unconnected, indicating that the test is unreliable. The observed reliability coefficient was 0.78, whereas the acceptable reliability value is 0.7. This indicated that the instruments were reliable (Mugenda & Mugenda, 2003).

An analysis using a combination of methods guarantees that qualitative findings will supplement quantitative findings (quantitative). In order to draw accurate conclusions from mixed data sets, the researcher needs to combine quantitative and qualitative findings in a way that is consistent with logic (Powell et al., 2008). When analyzing quantitative data, the researcher utilized descriptive statistics, and when analyzing qualitative data, content analysis was used. Quantitative analysis of the data relied on descriptive statistics, including the use of frequency and tables. The data collected from the interviews with the teachers and students was used to categories the difficulties

associated with mathematical symbolization and the instructional strategies. We conducted a content analysis on the interview transcripts.

3.8 Pilot Study

A pilot study was conducted to test the adequacy of the language and the effectiveness of the questionnaire in eliciting the necessary information. The pilot involved administering a preliminary version of the questionnaire to a small, representative sample similar to the main study participants. Feedback from this pilot study provided insights into the clarity and relevance of the questions, identifying any potential issues (Jupp, 2006). Based on the feedback, revisions were made to improve the instruments, ensuring that the final version was well-suited to gather accurate and relevant data for the main study (Fink, 2017). This process of refining the instruments through piloting was essential for enhancing their validity and ensuring that they effectively measured the intended constructs.

3.9 Ethical Consideration

The researcher was able to get permission to carry out the study from the Department of Curriculum Instruction and Media at Moi University's School of Education, as well as from the participants in the survey who filled out the questionnaire. The Ministry of Education, the Baringo County Education Office, and the principals of the response schools all received letters.

The researcher conveyed the study's nature and goal to the respondent. The respondent's right to maintain their confidentiality and integrity was honored by the researcher. The study participants were informed that the information they provided would be kept completely confidential and used only for the objectives of the study. After the classes

ended at 4 p.m., the questionnaire was administered. The participants were not forced to take part in this study; instead, they chose to do so.

CHAPTER FOUR

DATA ANALYSIS AND PRESENTATION

4.1 Introduction

In relation to the objectives of the research, the analysis and interpretation of the data are the primary focuses of this chapter.

4.2 Response Rate

The form three students were given 350 questionnaires by the researcher. The researcher received 340 replies, which represents 97 percent of the sample population's response. There were ten questionnaires that were excluded and could not be utilized in the final work since they contained a number of missing data or respondents provided personal information on the questionnaires, making them unusable for the study.

4.3 Demographic Data

4.3.1 Respondent's Gender

Table 1: Gender of the respondent

Gender	Frequency	Percentage (%)
Male	204	60
Female	136	40
Total	340	100

Source: (Researcher, 2019)

According to the data, 204 (60 percent) of the respondents were male, while 136 (40 percent) were female (table 1). The majority of the participants (60%) were male, which can be closely linked to the fact that males dominate mathematics courses.

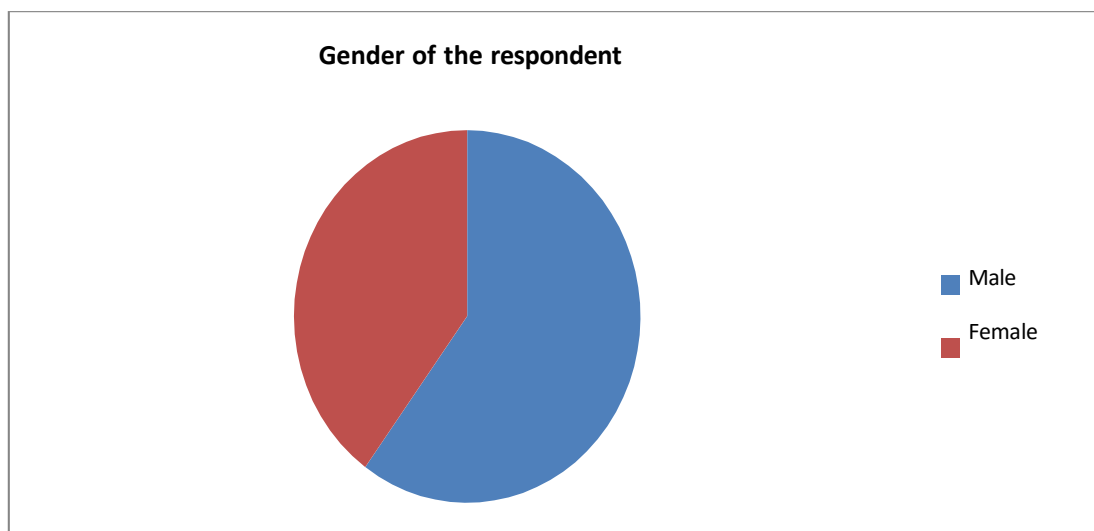


Figure 2: Gender of the respondent

Source: (Researcher, 2019)

4.3.2 Type of the school

Table 2: Type of the school

Type of school	Frequency	Percentage (%)
Private	1	4
Public	24	96
Total	25	100

Source: (Researcher, 2019)

The findings as shown in the table above indicate that 1 (4%) come from private schools and 24(96%) come from public secondary school. From the results, it is clear that of the majority of respondent school were public schools.

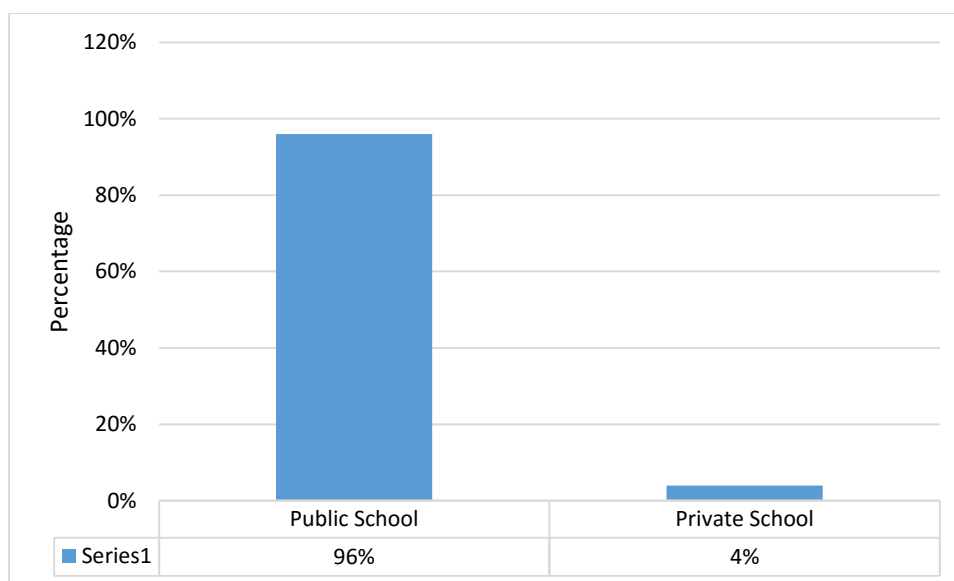


Figure 3: Bar graph on type of school

4.4 Findings on the Objectives of the Study

4.4.1 Extent to which mathematical symbols influence learners' performance in mathematics

The study sought to determine the extent to which mathematical symbols influence form three students' performance in mathematics in Koibatek Sub County, Baringo County.

Table 3: Extent to which mathematical symbols influence learners' performance in mathematics

Statement		SA	A	N	D	SD	N
My grasp of mathematical concepts is influenced by mathematical symbols.	Frequency	92	158	87	3	0	340
	Percentage	27	46.5	25.9	0.9	0.0	100
Understanding the formulae and symbols used in today's textbooks	Frequency	0	20	90	54	176	340
	Percentage	0.0	5.9	26.5	15.8	51.8	100
Ability to convey word problems concisely and effectively with the use of relevant symbols	Frequency	0	48	0	100	192	340
	percentage	0.0	14.1	0.0	29.4	56.5	100
When I am unable to cope with certain symbols, I seek assistance.	Frequency	97	183	60	0	0	340
	Percentage	28.5	53.8	17.7	0.0	0.0	100
Students' ability to use relevant symbols to manipulate expressions and equations.	Frequency	0	169	81	70	20	340
	Percentage	0.0	49.7	23.8	20.6	5.9	100

The study findings on how mathematical symbols influence students' grasp of mathematical concepts indicate that 92 students (27%) neither agreed nor disagreed, 158 students (46.5%) agreed, and 92 students (27%) strongly agreed. This shows that a majority of 73.5% of the respondents recognize that mathematical symbols significantly impact their understanding of mathematical concepts, thereby influencing their performance in mathematics.

When examining students' understanding of the formulae and symbols used in today's textbooks, the results revealed that 176 students (51.8%) strongly disagreed, 90 students (26.5%) were neutral, 54 students (15.8%) disagreed, and 20 students (5.9%) agreed. The majority of respondents (51.8%) strongly disagree with the statement that they understand the formulae and symbols in current textbooks. This suggests a clear need for teachers to provide more guidance in interpreting and using these formulae and symbols to improve students' comprehension of mathematical concepts.

Regarding the ability to convey word problems concisely and effectively using relevant symbols, the responses were as follows: 192 students (56.5%) strongly disagreed, 100 students (29.4%) disagreed, and 48 students (14.1%) agreed. The data indicates that a majority of Form Three students (56.5%) strongly disagree with the ability to effectively use symbols for word problems, while only a minority (14.1%) agreed. This highlights that many students struggle to use symbols effectively in word problems, which can negatively impact their mathematical performance.

On the question of whether students seek assistance when unable to cope with certain symbols, 60 students (17.7%) were neutral, 183 students (53.8%) agreed, and 97 students (28.5%) strongly agreed. This shows that a majority (82.3%) of Form Three

students seek help when struggling with symbols, indicating that they actively seek support to overcome difficulties with symbolic understanding.

The findings on students' ability to use relevant symbols to manipulate expressions and equations were as follows: 169 students (49.7%) agreed, 81 students (23.8%) were neutral, 70 students (20.6%) disagreed, and 20 students (5.8%) strongly disagreed. Despite a majority (49.7%) indicating that they can use symbols to manipulate expressions and equations, a significant number of students (26.4%) disagreed or strongly disagreed. This suggests that many students face difficulties in applying symbols effectively, which impacts their overall performance in mathematics.

According to the study, approximately 90% of the teachers interviewed agreed that learners' ability to develop expertise in using symbols and understanding mathematical skills is influenced by their grasp of mathematical symbols. Collis (2015) observed that making sense of mathematical symbols is a challenging aspect of learning, as symbols are often viewed either as shorthand or as standalone items. Symbols play a critical role in bridging informal mathematical understanding with abstract mathematical concepts. They enable teachers to effectively convey mathematical concepts and help students make meaningful connections through symbolic manipulation.

4.4.2 Strategies used in teaching mathematical symbols and how they influence students' performance in mathematics.

Table 4: Strategies used in teaching mathematical symbols

Statement		SA	A	N	D	SD	N
Visual aids improve students' understanding of mathematical symbols.	Frequency	188	94	10	37	11	340
	Percent	55.3	27.6	2.9	10.9	3.2	100
Teacher demonstrations on applying symbols enhance comprehension and problem-solving.	Frequency	180	112	25	13	10	340
	Percent	52.9	32.9	7.4	3.8	2.9	100
Students' active involvement in demonstrations strengthens their understanding of symbols.	Frequency	90	168	2	48	32	340
	Percent	26.5	49.4	0.59	14.1	9.4	100
Clear, logical demonstrations improve students' grasp of mathematical symbols.	Frequency	130	144	31	31	4	340
	Percent	38.2	42.4	9.1	9.1	1.2	100
Introducing unfamiliar symbols in demonstrations boosts critical thinking and performance.	Frequency	88	187	12	33	20	340
	Percent	25.9	55	3.5	9.7	5.9	100

The study findings on the use of visual aids as a strategy to improve understanding of mathematical symbols indicated that 10 (2.9%) neither agreed nor disagreed, 94 (27.6%) agreed, and 188 (55.3%) strongly agreed. It is clear from the results that the majority, 82.9%, agreed that visual aids positively impact students' understanding of mathematical symbols, thus influencing their performance in mathematics.

Regarding the use of teacher demonstrations in applying symbols, the results showed that 112 (32.9%) agreed, 25 (7.4%) were neutral, 13 (3.8%) disagreed, and 180 (52.9%) strongly agreed. From the findings, over 80% of the respondents agreed that teacher demonstrations significantly enhance student understanding and problem-solving skills in mathematics.

On students' involvement in demonstrations, 90 (26.5%) strongly agreed, 168 (49.4%) agreed, while 80 (23.5%) disagreed. The results reveal that a majority, 75.9%, believed

that their active involvement in demonstrations strengthens their understanding of mathematical symbols.

The study findings on the clarity and logical progression of demonstrations showed that 31 (9.1%) were neutral, 144 (42.4%) agreed, and 130 (38.2%) strongly agreed. From the results, it is evident that over 80% of the respondents agreed that clear, logical demonstrations improve their understanding of mathematical symbols and positively affect their performance.

Regarding the introduction of unfamiliar symbols during demonstrations, the responses were as follows: 187 (55%) agreed, 12 (3.5%) were neutral, 33 (9.7%) disagreed and 20 (5.9%) strongly disagreed. The results indicate that most respondents agreed that unfamiliar symbols introduced during demonstrations challenge students and promote critical thinking, though they may negatively affect problem-solving for some learners.

Teachers were interviewed on the specific strategies they used when teaching mathematics content with symbols, most of the teachers interviewed indicated that they mostly use drawings when illustrating mathematical content with symbols to their students. Giving meaning to each symbol they use, they ask students to draw pictures or diagrams when faced with a problem. Students are encouraged to solve problems using numbers and symbols instead of actual items or visual representations since these representations assist them link and solve the same topics taught previously using concrete objects. Students are frequently required to memorize concepts and algorithms in addition to developing fluency." The use of demonstration while teaching mathematics was also another strategy employed by mathematics teachers. Approximately 80% of the teachers interviewed revealed that for the student to understand some concepts.

The students select a response card from the stack and display it to demonstrate their decision." The students participate in formal mathematics groups and logical arguments with their students as a strategy in teaching mathematics symbolic language, these strategies employed by teachers has positively influenced form three performance in mathematics. According to Vacca & Vacca (2005), a learner's past knowledge is the one most essential resource in learning a mathematics text. To make sense of the new information, each student actively draws on existing knowledge and experience. Learners will benefit from and retain what they read if they bring more symbol knowledge and abilities to the text. Activating prior knowledge helps students create logical connections, make conclusions, and acquire new ideas.

4.4.3 Challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem-solving procedures and their influence on students' performance in mathematics

Table 5: Challenges that secondary school students encounter when interpreting and applying mathematical symbols

Statement		SA	A	N	D	SD	N
There is poor attitude by students towards mathematical symbols	Frequency	186	97	12	33	12	340
	Percent	54.8	28.5	3.5	9.7	3.5	100
There is anxiety by students towards mathematical symbols	Frequency	154	140	22	8	4.7	340
	Percent	42.8	41.2	6.5	2.4	2.9	100
There is self-doubt towards mathematical symbols by learners	Frequency	104	82	42	53	59	340
	Percent	30.6	24.1	12.4	15.6	17.4	100
Students frequently rush through tasks involving mathematical symbols without careful consideration.	Frequency	98	56	43	89	54	340
	Percent	28.8	16.5	12.6	26.2	15.9	100
Students commonly misinterpret or misread mathematical symbols in problem statements.	Frequency	83	102	32	74	49	340
	Percent	24.4	30	9.4	21.8	14.4	100

The study findings on the attitude by students towards mathematics the results indicated that, A significant number of respondents, 186 students (54.8%), strongly agreed that they had a poor attitude toward mathematical symbols, while 97 students (28.5%) agreed. Only 33 students (9.7%) disagreed, and 12 students (3.5%) both strongly disagreed and were neutral. This indicated that a majority of students had struggled with a negative attitude toward mathematical symbols, which was a major barrier to understanding mathematical concepts.

Regarding anxiety, 154 students (42.8%) had strongly agreed, and 140 students (41.2%) had agreed that they felt anxious when dealing with mathematical symbols. A small group of 22 students (6.5%) had remained neutral, while only 8 students (2.4%) had disagreed. This showed that anxiety had been a significant issue for most students in interpreting mathematical symbols.

Self-doubt was another challenge, with 104 students (30.6%) having strongly agreed, and 82 students (24.1%) having agreed that they experienced self-doubt when working with mathematical symbols. A notable portion, 59 students (17.4%), had strongly disagreed, while 53 students (15.6%) had disagreed. This suggested that although self-doubt had been prevalent, a substantial number of students did not experience it.

When asked about whether students frequently rush through tasks involving mathematical symbols without careful consideration, 98 students (28.8%) strongly agreed, and 56 students (16.5%) agreed. In contrast, 89 students (26.2%) disagreed, and 54 students (15.9%) strongly disagreed, suggesting that while a significant number of students rush through tasks, there is also a notable proportion who take more time to consider the tasks.

Regarding the challenge of misinterpreting or misreading mathematical symbols in problem statements, 83 students (24.4%) strongly agreed, and 102 students (30%) agreed that they often misinterpret symbols. However, 74 students (21.8%) disagreed, and 49 students (14.4%) strongly disagreed, indicating that while many students struggle with misreading symbols, others are more accurate in their interpretations.

On the findings on the challenges students encounter when interpreting and using mathematical symbols, most teachers identified poor student attitude as the major challenge secondary school students, particularly form three students, face when interpreting and using mathematics symbols to comprehend mathematical concepts. Everything rests on one's attitude toward the subject in question. The mindset of the learner is crucial. If a student believes from the start that he would not be able to succeed in the discipline, he will develop a fear of mathematics. This, in turn, will have an impact on his ability to learn and perform. A cheerful mindset can make a significant difference. It will increase one's confidence. "In fact, many students remark about how uninteresting mathematics is. They might not see the benefit of mastering geometry, algebra or calculus in school or they may wonder why they need to know how to do basic mathematics like additions, subtraction, multiplication, and division by hand when the solutions can easily be obtained using a calculator or computer," one of the teachers said.

Math is a subject, according to approximately 75 percent of the educators who were interviewed, in which psychological factors, such as anxiety, have a significant impact on a student's level of achievement. Anxiety is a chemical process in the brain that can obstruct cognitive processes and generate physical symptoms such as rapid breathing, heart palpitations, and perspiration. Anxiety is distinct from worry because anxiety is a chemical process in the brain. Even if they are normally excellent students, people who

suffer from math anxiety may become paralysed during a test or quiz involving the subject. According to the math professors who were interviewed for this article, students have difficulty finding their way into a problem, misunderstand questions, and complete a significantly lower percentage of questions than they are capable of. "Many anxious students make careless mistakes as a result of the stress they are facing at the time, and the quality of their work during timed assessments is generally of a lower standard than that of class activities or assignments performed at home," one of the teachers explained.

Other challenges encountered by students were self-doubt, this hampers learners' self-confidence, this hampers student ability to interpret and use mathematical symbols to understand mathematical language, students may not express themselves, but they are terrified of the subject. They are on the lookout for strategies to avoid having to be taught mathematics. Another reason learners fail in mathematics is peer pressure. They can't handle the pressure to do well at school. Self-doubt arises as a result of this, as well as continuous comparisons with other good students. They may not express themselves, but they are terrified of the issue. They look for ways of avoiding having to learn the subject.

The findings on students' own interpretation of mathematical symbols contradicts with its actual interpretation in English hamper students' progress in solving mathematical problems. Most of the teachers indicated Yes, student own interpretation of mathematical symbols contradicts that of English this hampers students' progress in solving mathematical problems. The results of this study show that students should construct algebraic expressions or equations by translating the given word problems phrase by phrase. When probed further into their responses, they all pointed to the same problem. The findings from the learners were in agreement, since most agreed that own

interpretation of mathematical symbols contradicts with its actual interpretation in English, which hamper students' progress in solving mathematical problems thus influencing their performance in mathematics. According to Clement (1982), there are two explanations for such misunderstandings. The first is static compression, while the second is word order matching. As a result of this style of understanding, students interpreted the situation incorrectly. Non-English speakers may need extra help to benefit from communication-rich math classes, but they can fully participate if classroom activities are handled properly (Ferreira, 2011).

The findings on do students complete their maths activities quickly and with a thorough understanding of the features and symbols involved, teachers indicated that a thorough understanding of the features and symbols used in a problem helped students get their maths tasks done quickly. Knowing how to utilize mathematics' language effectively in everyday conversation is an important part of mastering the subject. Although mathematics is frequently communicated using symbols, spoken and written communication regarding mathematical ideas is often not considered as a critical component of mathematics education. Because students do not naturally converse about mathematics, teachers must assist them in learning how to do so (O'Connell and Croskey, 2007).

Mathematical communication is a technique that students must master. Learners must regularly engage in debate and discussion about mathematics-related topics, as well as discover mathematical symbols. Majority of the form three learners strongly agreed that they struggle to give meaning to the symbols and this negatively affect their conceptualization of the mathematical symbols, thus affecting their performance in mathematics.

Siegel and Fonzi (1995) conducted studies that revealed a lack of verbal interchange between students and their peers, as well as between students and their teachers, in the classroom, portraying classrooms as a conventional input/output setting. Teachers should be able to relinquish some control over their classroom's instructional environment and allow students to be more than merely passive recipients of the materials they must master. One of the methods to engage learners in formative assessment is to have them discuss mathematical topics. Learners may also realize what they don't comprehend, which is a bonus. This enables them to fine-tune their reasoning, which may increase their metacognitive talents over time. Teaching through conversation boosts memory, deeper reasoning, language development, and social skills, all of which help students learn more effectively (Coe, Aloisi, Higgins & Major, 2014).

CHAPTER FIVE

SUMMARY OF THE FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Introduction

This chapter summarizes, concludes, and discusses the conclusions reported in Chapter 4. Conclusions based on the study's findings are presented. The objectives are crucial to the interpretation and discussion. The purpose of this study was to examine the influence of mathematical symbols on the learner performance in Koibatek secondary schools in Baringo County, Kenya. Specifically, the study sought to establish the extent to which mathematical symbols influence students' performance in mathematics, strategies used in teaching mathematical symbols and how they influence students' performance in mathematics and finally challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem solving procedures among form three students in Koibatek Sub-County Baringo County.

5.2 Summary of the Key Findings

5.2.1 Extent to which mathematics symbols influence students' performance in mathematics

Majority of the teachers indicated that mathematics symbols actually influence the ability of the learner to gain skills in symbol use and situation interpretation. One of the most challenging aspects of studying is making sense of words (letters). Symbols affect a student's ability to connect informal and abstract mathematics. Creating learning settings that encourage learners to connect formal and informal mathematics knowledge and using problem-specific representations can help learners learn written symbols.

Majority of the teachers responded that their students encounter the difficult of misinterpretation of symbols for example $>$ is misinterpreted to mean less than and $<$ is taken as greater than, the study also reveals that most form three students have a challenge in writing of symbols, for example sigma in statistics topic, a sum of numerous terms is usually denoted by the symbol (σ). This symbol is usually followed with a variable index that includes all terms which must be included in the sum. The learners wrote to denote a sum of only a single term. Another difficulty student encounter while solving mathematical symbols in mathematical problems was confusion of symbols, Symbols can be challenging to teach to students who do not yet understand the concepts they represent.

Teachers often add to students' difficulties at this level by asking them to match pictured clusters with number sentences before they've had enough practise connecting physical representations to mathematical symbols and words. Because they can be moved, handled, gathered, and separated, concrete items are more vivid than pictures.

5.2.2 Strategies used in Teaching Mathematical Symbols and their Influence on Students' Performance in Mathematics

Based on the second objective on strategies used in teaching mathematical symbols and how they influence students' performance in mathematics.

The use of demonstration while teaching mathematics was the main strategy employed by mathematics teachers, approximately 60% of the teachers interviewed revealed that for the student to understand some concepts they use, they mostly demonstrate it on the chalkboard or using diagrams/ pictorials. Another strategy used was questioning strategy, this is a strategy where the teacher examines students' understanding before evaluating and adjusting their instruction as needed based on the information gathered

from the inquiry. The students participate in formal mathematics groups and logical arguments with their students as a strategy in teaching mathematics symbolic language, these strategies employed by teachers has positively influence form three performance in mathematics

Their responses were in agreement with the learners response where they strongly agreed that students' failure to understand an idea or topic is marked by the presence of unfamiliar mathematical symbols thus affecting their performance in mathematic. Majority of the teachers responded that mathematics questions being wordy and full of symbols, learners performance does not in any way become outstanding.

5.2.3 Challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem-solving procedures and their influence on students' performance in mathematics

Poor student attitude was revealed as the major challenge secondary school learners, especially form three, face when reading and using mathematics symbols to comprehend mathematical concepts. Everything is determined by one's attitude toward the matter at hand. The mindset of the learner is crucial. If a student believes from the outset that he would not be able to succeed in the area, he will acquire a fear of mathematics. This, in turn, will have an impact on his ability to learn and perform. A cheerful mindset can make a significant difference. It will increase your self-esteem in mathematics.

Student ability to interpret and use mathematical symbols to understand mathematical language, Students may not express it, but they are terrified of the subject. Peer influence is another cause why learners fail in mathematics. Other problem affecting

form three students was that interpretation of mathematical symbols contradicts that of English this hampers students' progress in solving mathematical problems. Students developed algebraic expressions and equations in word problems, according to the findings of this study, by translating the given word problem from phrase to phrase. When probed further into their responses, they were all referring to the same problem. The majority of teachers said that having a good comprehension of the symbols and characteristics utilized in the task aided pupils in completing their math homework promptly. Students were able to complete their activities more rapidly by having a firm grasp on the symbols, features, and mathematical terminologies.

5.3 Conclusion

The study revealed that the use and understanding of mathematical symbols significantly influence students' performance in mathematics. Many students struggle with the interpretation and proper application of symbols, which impedes their ability to connect informal and abstract mathematics concepts. Misinterpretation of symbols, such as mistaking "<" for greater than or misunderstanding symbols like sigma (Σ), leads to confusion and incorrect problem-solving approaches. This highlights the importance of building a strong foundation in symbol recognition and interpretation for effective learning in mathematics.

The research found that strategies like demonstration, questioning, and group discussions are commonly employed by teachers to facilitate the understanding of mathematical symbols. Demonstrations, often using diagrams or pictorial representations, help students visually connect symbols to mathematical concepts. Questioning strategies encourage active student engagement, allowing teachers to assess comprehension in real-time and adjust instruction accordingly. These strategies

have positively influenced students' performance, as evidenced by the improvement of students who actively participate in formal mathematics groups and logical arguments.

The study identified several challenges faced by students when interpreting and applying mathematical symbols. A key challenge is the negative attitude many students hold toward mathematics, which affects their willingness to engage with mathematical symbols. This fear or apprehension, often exacerbated by peer influence, hinders their ability to fully understand and use mathematical symbols. Furthermore, the contradiction between the interpretation of symbols in mathematics and in English contributes to confusion. Students often translate word problems incorrectly, resulting in poor performance. These findings suggest the need for focused interventions to improve students' attitude toward mathematics and enhance their symbolic literacy.

5.4 Recommendations

Based on the research findings and conclusion the study makes the following recommendations, that:

- i. It is recommended that teachers adopt a more focused approach when teaching mathematical symbols. Specific instructional strategies should be developed to enhance students' understanding and application of these symbols, which are fundamental to grasping mathematical concepts. Teacher training programs should emphasize the importance of symbol mastery in mathematics instruction.
- ii. The Ministry of Education should consider revising the mathematics curriculum to include more structured lessons on mathematical symbols, ensuring they are consistently integrated into problem-solving activities. The

curriculum should also provide guidelines on teaching methods that enhance students' familiarity with mathematical symbols.

- iii. Professional development programs should be initiated to equip mathematics teachers with effective pedagogical techniques for teaching mathematical symbols. This includes workshops, seminars, and continuous in-service training focused on improving teachers' ability to explain symbols clearly and in various contexts to support student learning.
- iv. Schools should conduct regular assessments to identify students who struggle with interpreting and applying mathematical symbols. Support systems, such as remedial classes and peer tutoring, can be introduced to help these students overcome difficulties and improve their overall mathematics performance.
- v. Future studies should explore the impact of teaching mathematical symbols in different regions or settings, comparing results across various educational environments. Expanding research beyond Koibatek Sub-County would help generalize the findings and offer broader insights into the role of symbols in mathematics education.
- vi. Education policymakers should develop guidelines that emphasize the teaching and assessment of mathematical symbols in both internal and national exams. Adequate weighting on the correct interpretation and use of symbols in assessments could motivate students to focus more on mastering this critical area.

5.5 Suggestions for Further Research

The report offers the following areas for additional research based on its results and conclusions;

- i. A study will be done to determine why many secondary school teachers do not incorporate different teaching and learning activities into their teaching techniques, which is critical in encouraging students' interests.
- ii. A similar study should be done in other parts of the country in order to facilitate comparison and finally conclusion

REFERENCES

- Adams, T. L. (2003). Reading mathematics: More than words can say. *The Reading Teacher*, 56(8), 786-795.
- Amadalo, M. M. (2013). Students' Attitudes towards Physics in Nine Years Basic Education in Rwanda. *International Journal of Evaluation and Research in Education*, 10(2), 648-659.
- Ary, D., Jacobs, L.C. & Razavieh, A., (1985). *Introduction to Research in Education*. New York: Holt, Rinehart and Winston.
- Azevedo, F., Carvalho, M. A., & Silva, P. (2023). Conceptual understanding and symbol usage in mathematics: Addressing students' difficulties. *Journal of Educational Research*, 116(3), 354-369.
- Bakker, A., & Gravemeijer, K. (2022). The role of technology in teaching mathematical symbols: An updated review. *Educational Technology Research and Development*, 70(2), 563-580.
- Black, P., & Wiliam, D. (2018). Assessment and classroom learning. *Assessment in Education: Principles, Policies, and Practices*, 5(1), 7-74.
- Boaler, J. (2002). *Experiencing school mathematics: Traditional and reform approaches to teaching and their impact on student learning*. Routledge.
- Bell, A.W., Costello, J. & Kuchemann, D.E., (1983). *A Review of Research in Mathematical Education; Part A: Research on Learning and Teaching*. Windsor, Berks: NFER Nelson Publishing Coy Ltd.
- Boorman, N. N. (2015). The Socioeconomic Status Label Associated With Mathematics. In *Global Ideologies Surrounding Children's Rights and Social Justice* (pp. 186-203). IGI Global.
- Common Core State Standards Initiative. (2020). *Common Core State Standards for Mathematics*.
- Bossé, M. J., & Faulconer, J. (2008). Learning and assessing mathematics through reading and writing. *School Science and Mathematics*, 108(1), 8-19.
- Charlesworth, I., (2015). On two-faced families of non-commutative random variables. *Canadian Journal of Mathematics*, 67(6), 1290-1325.
- Cho, H. H., & Choi, K. H. (2002). Science education: Constructivist perspectives. *Journal of the Korean Association for Science Education*, 22(4), 820-836.
- Chen, X., & Li, X. (2023). Targeted interventions for overcoming difficulties with mathematical symbols. *Mathematics Education Research Journal*, 35(1), 45-60.
- Clements, D. H., & Sarama, J. (2019). *Teaching mathematics in early childhood: Research-based practices*. Routledge.

- Clements, D. H., (2004). *Measurement in pre-K to grade 2 mathematics. Engaging young children in mathematics: Standards for early childhood mathematics education*, 299-317.
- Chapman, L.R., ed. (1972). *The Process of Learning Mathematics*. Oxford: Pergamon Press Ltd.
- Clement, J. (1982). Students' preconceptions in introductory mechanics. *American Journal of Physics*, 50, 66-71
- Daroczy, G., Artemenko, C., Meurers, D., Wolska, M., & Nuerk, H. C. (2015). *Influence of Task Characteristics on Eye-Movement Patterns Related to Numerical and Textual Information in Arithmetic Word Problems*.
- Duval, F. (2006). Connecting Research to Teaching: Visualizing as a Mathematical Way of Knowing: Understanding Figural Generalization. *The mathematics teacher*, 101(1), 69- 75.
- Dienes, Z.P., (1963). *An Experimental Study of Mathematics Learning*. London: Hutchison and Co.Ltd.
- Earle, R.A., (1977). *Teaching Reading and Mathematics*. Delaware: International Reading Association.
- Esty, W., (2011). *The Language of Mathematics*. Retrieved on 06/12/11 from <http://www.augustusmath.hypermath.net>
- Ertmer, C., Westphal, M., Rehberg, S., Kampmeier, T., Ligges, S., ... & Singer, M. (2013). Effect of heart rate control with esmolol on hemodynamic and clinical outcomes in patients with septic shock: a randomized clinical trial. *Jama*, 310(16), 1683-1691.
- Esteve, M. R. M. (2008). Symbolic language in early modern mathematics: The Algebra of Pierre Hérigone (1580–1643). *Historia Mathematica*, 35(4), 285-301.
- Farrugia, M. T. (2013). Moving from informal to formal mathematical language in Maltese classrooms. *International Journal of Bilingual Education and Bilingualism*, 16(5), 570- 588.
- Fricke, I., Horak, E., Meyer, L., & Van Lingen, N. (2008). Lessons from a mathematics and science intervention programme in Tshwane township schools. *South African Journal of Higher Education*, 22(1), 64-77.
- Fuchs, L. S., & Fuchs, D. (2007). A model for implementing responsiveness to intervention. *Teaching Exceptional Children*, 39(5), 14-20.
- Funke, J. (2010). Complex problem solving: a case for complex cognition. *Cognitive Processing*, 11(2), 133-142.
- Fyfe, E. R., McNeil, N. M., Son, J. Y., & Goldstone, R. L. (2014). Concreteness fading in mathematics and science instruction: A systematic review. *Educational Psychology Review*, 26 (1), 9-25.

- Flouris, G., Calogiannakis-Hourdakis, P., Spiridakis, J., & Campbell, J.R., (1994). Tradition and Socio- Economic Status Are Greek Keys to Academic Success. *International Journal of Educational Research* (21), 7, pp. 705-712.
- Gambari, A. I., (2013). Students' Perception towards the use of computer-assisted instruction on learning mathematics in Minna, Niger State, Nigeria. *International Journal of Behavioral Sciences*, 4(1), 14-21.
- Ganesalingam, M. (2013). The language of mathematics. In *The language of mathematics* (pp.17-38). Springer, Berlin, Heidelberg.
- Grootenboer, P., & Hemmings, B. (2022). Student challenges with mathematical symbols and their impact on performance. *International Journal of Mathematics Education*, 54(1), 22-38.
- Garegae, K.G., (2011). *Language in Mathematics Education. A double Jeopardy for Second Language Learners*. Retrieved on 15/12/11 from <http://www.ts.g.icme11.org/document/get/120>
- Gillham, B. (2000). *Developing a questionnaire*. London: Continuum
- Given, L. M. (Ed.). (2008). *The Sage Encyclopaedia of Qualitative Research Methods*. New Delhi: Sage Publications.
- Godino, J. D., & Batanero, C., (2003). The onto-semiotic approach to research in mathematics education. *Zdm*, 39(1), 127-135.
- Goldstone, R. L., (2012). Introduction to "new conceptualizations of transfer of learning". *Educational Psychologist*, 47(3), 149-152.
- Gouba, L. (2008). The importance of mathematics in everyday life. *African Institute for mathematical Sciences*, 6.
- Jan, S., & Rodrigues, S. (2012). Learners' difficulties in comprehending mathematical word problems in English language learning contexts. *International Researcher*, 1(3), 152 160.
- Hattie, J., & Timperley, H. (2021). The power of feedback in mathematics instruction. *Review of Educational Research*, 91(2), 345-362.
- Huang, T. H., Chen, C. H., & Chien, S. Y. (2020). Visual aids in the teaching of mathematical symbols: A meta-analysis. *Educational Psychology Review*, 32(4), 1127-1149.
- Hennessy, S. (2023). The role of technology in the teaching and learning of mathematics: A review of research and future directions. *Research in Mathematics Education*, 15(2), 139-158.
- Hiebert, J., & Carpenter, T. P. (2022). Learning and teaching with understanding. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 65-97). Macmillan.
- IEA. (2019). TIMSS 2019 International Results in Mathematics and Science.
- Jansen, M., & Sälzer, C. (2021). The impact of symbolic notation on mathematical performance: A longitudinal study. *Educational Studies in Mathematics*, 106(3), 287-304.

- Jao, L. (2012). The multicultural mathematics classroom. *Multicultural Education*, 19(3), 2-10.
- Joan, D. R. (2015). An Introduction to Various Types of Mathematics Teaching Aids. *I- Manager's Journal on Mathematics*, 4(2), 1-10.
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26.
- Johnson, R.B., & Christensen, L. (2013). *Educational Research: Quantitative, Qualitative and Mixed Approaches* (5th Edn). New Delhi: Sage.
- Jablonka, E. (2003). Mathematical literacy. In *Second international handbook of mathematics education* (pp. 75-102). Springer, Dordrecht.
- Jojo, Z. M. M. (2014). Representation of the Equal Relationship in the Development of Mathematical Thinking: A Case of Grade One's. *Mediterranean Journal of Social Sciences*, 5(23), 914.
- Jolley, K. D. (2014). *Wittgenstein: key concepts*. Thousand oaks: Routledge.
- Karue, N., & Amukowa, W. (2013). Analysis of Factors that Lead to Poor Performance in Kenya Certificate of Secondary Examination in Embu District in Kenya. Retrieved on 19th October, 2014 from <http://www.tijoss.com/TIJOSS%2013th%20Volume/Amukowa.pdf>
- Kline, M., (1972). *Mathematical Thought from Ancient to Modern Times*. New York: Oxford University Press.
- Kuster, J., (2010). Math Never Seen. *TUGboat* (31), 2, pp. 221-229.
- Kaput, J. J. (1985). A joint perspective on the idea of representation in learning and doing mathematics. In *Theories of mathematical learning* (pp. 409-442). Routledge.
- Kihlstrom, P. L. (2011). *The flipped classroom: Cultivating student engagement*.
- Kollár, J. (2014). Automated language symbolization and conceptualization in human-computer communication. In AIP Conference Proceedings (Vol. 1648, No. 1, p. 310003). AIP Publishing LLC.
- Kaput, J. J. (2018). Representation and mathematics. In A. E. Snow & J. H. K. Meyer (Eds.), *The role of representation in teaching and learning mathematics* (pp. 160-188). Routledge.
- Kvasnicka, V., (2008). Artificial chemistry and molecular Darwinian evolution of DNA/RNA-like systems I-typogenetics and chemostat. In *Computational intelligence in medical informatics* (pp. 295-336). Springer, Berlin, Heidelberg.
- Land, F.W., (1963). *New Approaches to Mathematics Teaching*. London: Macmillan and Co. Ltd.
- Lee, C., (1997). Teachers Can do Research. *Mathematics Teaching* (158), pp. 8-11.
- Lewellen, B. L., (2008). Magnetically targeted viral envelopes: a PET investigation of initial biodistribution. *IEEE transactions on nanobioscience*, 7(3), 223-232.

- Lee, X., (2004). *The Problems of Traditional Math Notation*. Retrieved 06/12/11 from Silvanos Chirume http://www.xahlee.org/cmaci/notation/trad_math_notation.html
- Luna, C.A. & Fuscablo, L.G., (2002). Enhancement of Student Problem Solving Performance through Mathematical Symbolism. Proceedings of ICME10-Topic Study Group 9, pp. 1- 10.
- Marjoram, D.T.E., (1974). *Teaching Mathematics*. London: Heinemann Educational Books.
- Nelson, R.D., (1980). *The penguin book of mathematical and statistical tables*. Harmondsworth: Penguin Books Ltd.
- Mugenda, O. M., & Mugenda, A. G. (2013). *Research methods. Quantitative and qualitative approaches*, 46-48.
- Matejko, A. A. & Ansari, D., (2016). Teachers as orchestrators of neuronal plasticity: Effects of teaching practices on the brain. *Mind, Brain, and Education*, 14(4), 415-428.
- Miheso, K. M. (2012). *Factors affecting mathematics performance among secondary students in Nairobi*. Unpublished M. ed thesis. Kenyatta University.
- Miller, J. L., & Koeske, G. (2020). The effects of visual aids on mathematical understanding. *Journal of Educational Psychology*, 92(2), 426-434.
- Moodley, I. (2016). Educational journeys of foundation phase teachers in the context of curriculum change (Doctoral dissertation).
- McNeil, N. M., & Alibali, M. W. (2018). Mathematical symbols as cognitive tools: The impact on problem-solving. *Cognition and Instruction*, 36(1), 56-77.
- Miller, J. L., & Koeske, G. (2020). The role of symbolic notation in mathematics achievement. *Journal of Educational Psychology*, 112(3), 489-504.
- Mutodi, P. (2016). Mathematical symbolization: Challenges and instructional strategies for Limpopo Province secondary school learners (Doctoral dissertation, Doctoral dissertation). University of South Africa, Pretoria, South Africa).
- Mutodi, P., & Ngirande, H. (2014). The influence of student's perceptions on Mathematics performance. A case of a selected high school in South Africa. *Mediterranean Journal of Social Sciences*, 5(3), 431.
- Neyland, J. (2004). Toward a postmodern ethics of mathematics education. *Mathematics education within the postmodern*, 55-73.
- Njoroge, B. (2003). Relationship between mathematical language and students' performance in mathematics in public secondary schools in Nairobi province, Kenya (Doctoral dissertation, Kenyatta University).
- Nathan, M. J. (2012). Rethinking formalisms in formal education. *Educational Psychologist*, 47(2), 125-148.
- Nathan, M. J., & Koellner, K. (2007). A framework for understanding and cultivating the transition from arithmetic to algebraic reasoning. *Mathematical Thinking and Learning*, 9(3), 179-192.

- Nathan, M. J., Long, S. D., & Alibali, M. W. (2002). The symbol precedence view of mathematical development: A corpus analysis of the rhetorical structure of textbooks. *Discourse Processes*, 33(1), 1-21.
- National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.
- NCETM. (n.d.). Professional Development
- Ololube, N. P., (2015). Barriers to Blended Teaching and Learning in Sub-Saharan Africa: Challenges for the next decade and beyond. In *Curriculum Design and Classroom Management: Concepts, Methodologies, Tools, and Applications* (pp. 846-861). IGI Global.
- OECD. (2018). *PISA 2018 Assessment and Analytical Framework*. OECD Publishing.
- Oluoch, R. (2000). Exploring Preservice Teachers' Perceptions of Classroom Cultural Diversity (Doctoral dissertation, Virginia Tech).
- Pimm, D. (1987). *Speaking Mathematically*. London: Routledge and Kegan Paul.
- Porkess, R., Vorderman, C., Budd, C., Dunne, R., & Hart, M. (2011). *A world-class mathematics education for all our young people*.
- Progressive Education Association, (2020). *Mathematics in General Education*. New York: Appleton- Century Crofts.
- Preston, M., (1978). The Language of Early Mathematical Experience. *Mathematics in School* (7), 4, pp. 31- 32.
- Phillips, D. C. (1995). The good, the bad, and the ugly: The many faces of constructivism. *Educational researcher*, 24(7), 5-12.
- Quinnell, L., & Carter, M. (2012). Greek or not: The use of symbols and abbreviations in mathematics. *Australian Mathematics Teacher*, 68(2), 34-40.
- Radford, D. (2006). The use of visual strategies by educators at tertiary level and its influence on student teachers' development of mathematical concepts (Doctoral dissertation).
- Rubenstein, R. N., & Thompson, D. R. (2001). Discuss with Your Colleagues: Learning Mathematical Symbolism: Challenges and Instructional Strategies. *The Mathematics Teacher*, 94(4), 265-271.
- Rukanga, J. K. (2011). Attitudes towards learning and performance in mathematics among students in selected secondary schools in Bureti district, Kenya. Unpublished Masters Dissertation.
- Rubenstein, R.N. & Thompson, D.R., (2001). Learning Mathematical Symbolism: Challenges \ and Instructional Strategies. *Mathematics Teacher* (94), 4, Reston, VA: NCTM.
- Rittle-Johnson, B., & Alibali, M. W. (2021). Understanding and using mathematical symbols: Challenges and strategies. *Journal of Research in Mathematics Education*, 52(2), 188-204.

- Savikko, N., Routasalo, P., Tilvis, R., & Pitkälä, K. (2010). Psychosocial group rehabilitation for lonely older people: favourable processes and mediating factors of the intervention leading to alleviated loneliness. *International Journal of Older People Nursing*, 5(1), 16- 24.
- Schleppegrell, M. J. (2007). The linguistic challenges of mathematics teaching and learning: A research review. *Reading & Writing Quarterly*, 23(2), 139-159.
- Schleppegrell, M. J. (2010). Language in mathematics teaching and learning. Language and mathematics education: In Moschkovich, J. N. (2010). *Multiple perspectives and directions for research*. Charlotte, NC: Information Age Publishing.
- Schliemann, A. D., & Carraher, D. W. (2002). The evolution of mathematical reasoning: Everyday versus idealized understandings. *Developmental Review*, 22(2), 242-266.
- Schwandt, T. A. (2017). *Qualitative inquiry: A dictionary of terms*. Thousand Oaks, CA: Sage.
- Shavelson, R. J., Webb, N. M., & Lehman, P. (2000). *The role of symbol systems in problem solving: a literature review*. Los Angeles: Graduate School of Education, University of California.
- Santos-Diaz, S., & Thomas, M. H. (2011). Using symbolic and graphical forms to analyze students' mathematical reasoning in chemical kinetics. *Journal of Chemical Education*, 95(12), 2114-2125.
- Sepeng, P., & Madzorera, A. (2014). Sources of difficulty in comprehending and solving mathematical word problems. *International Journal of Educational Sciences*, 6(2), 217- 225.
- Steinbring, H. (2006). What makes a sign a mathematical sign?—An epistemological perspective on mathematical interaction. *Educational studies in mathematics*, 61(1), 133-162.
- Sheikh, E., & Randa, S. N. (2013). Multiple Intelligences Theory and Its Effect in Raising the Van Hiele Levels of Thinking. Proceedings of the 2nd International Conference of Teaching and Learning (ICTL 2009) INTI University College, Malaysia.
- Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for information*, 22(2), 63-75.
- Smith, M. S., & Stein, M. K. (2011). 5 practices for orchestrating productive mathematics discussions. National Council of Teachers of Mathematics.
- UNESCO. (n.d.). Mathematics Education.
- Smith, M. P. W., Banks, R. E., Wood, S. L., Lewington, A. J., & Selby, P. J. (2009). Application of proteomic analysis to the study of renal diseases. *Nature Reviews Nephrology*, 5(12), 701.
- Sullivan, P., Clarke, D., & Clarke, B. (2021). Real-world applications of mathematical symbols: Enhancing student engagement and understanding. *Mathematics Education Research Journal*, 33(2), 187-204.

- Shepherd, M. D. (2005). Encouraging learners to read mathematics. *PRIMUS*, 15(2), 124- 144.
- Tall, D. (2009). Information Technology and Mathematics Education: Enthusiasms, Possibilities and Realities. *Colección Digital Eudoxus*, 1(6), 232-247.
- Tall, D., & Razali, M. R. (1993). Diagnosing learners' difficulties in learning mathematics. *International Journal of Mathematical Education in Science and Technology*, 24(2), 209- 222.
- Tall, D., Thomas, M., Davis, G., Gray, E., & Simpson, A. (1999). What is the object of the encapsulation of a process? *The Journal of Mathematical Behaviour*, 18(2), 223- 241.
- Tomlinson, C. A. (2001). *How to differentiate instruction in mixed-ability classrooms*. ASCD.
- Thomas, D., (2003). Model driven development: the case for domain-oriented programming. In Companion of the 18th annual ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications (pp. 2-7).
- Uchechi, I. E. (2013). Enhancing mathematics achievement of secondary school students using mastery learning approach. *Journal of emerging trends in educational research and policy studies*, 4(6), 848-854.
- Vinner, S. (2002). The role of definitions in the teaching and learning of mathematics. In *Advanced mathematical thinking* (pp. 65-81). Springer, Dordrecht.
- Vorderman, M., & Noyes, A. (2019). Mathematics in the disciplines at the transition to university. Teaching Mathematics and Its Applications: *International Journal of the IMA*, 38(2), 61-73.
- Welberry, T. R. (2009). *Diffuse scattering from molecular crystals* (pp. 181-209). Momentum Press: Highland Park, NJ.
- Wenno, I. H. (2015). The correlation study of interest at physics and knowledge of mathematics basic concepts towards the ability to solve physics problems of 7th grade students at junior high school in Ambon Maluku Province, Indonesia. Education Research International, 2015.
- Williams, K. (2010). Self-efficacy and performance in mathematics: Reciprocal determinism in 33 nations. *Journal of educational Psychology*, 102(2), 453.
- Yackel, E. (2000). *Introduction: Perspectives on semiotics and instructional design*. New Jersey: Lawrence Erlbaum Associates.
- Yerushalmy, M. (2005). Functions of interactive visual representations in interactive mathematical textbooks. *International Journal of Computers for Mathematical Learning*, 10(3), 217-249.
- Yetkin, E. (2003). Student difficulties in learning elementary mathematics. Columbus, OH: ERIC Digest. ERIC Clearing house for Science Mathematics and Environmental Education.

- Yusha'u, M. A. (2013). Difficult topics in junior secondary school mathematics: practical aspect of teaching and learning trigonometry. *Scientific Journal of Pure and Applied Sciences*, 2(4), 161-174.
- Wikipedia, (2010). *Abuse of Notation*. Retrieved on 06/01/12 from http://www.en.wikipedia.org/wiki/Abuse_of_notation
- Ward, R. G., Farrand, S. C., Hernandez, T. J., Neyland, R. A., Stupek, R. A., Barron, J. E., ... & Miller, A.J. (1994). U.S. Patent No. 5,367,670. Washington, DC: U.S. Patent and Trademark Office.
- Zohrabi, M. (2013). Mixed method research: Instruments, validity, reliability and reporting findings. *Theory and Practice in Language Studies*, 3(2), 254-262.
- Zorn, P. (2002). Algebra, computer algebra and mathematical thinking. Presentation at the 2nd International Conference on the Teaching of Mathematics, Hersonissos, <http://www.stolaf.edu/people/zorn/cretepaper.pdf>.
- Zvawanda, F. (2014). An insight into the teaching and learning of worded and simplified problems in Algebra at 'O'level at Pamushana High School in Bikita. Bindura: Bindura University.
- Zweng, M. (ed.). (2012). *Proceedings of the Fourth International Congress on Mathematical Education*. California: Springer Science & Business Media.
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APPENDICES

Appendix A: Letter of Introduction

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

I am a Masters student undertaking a master's programme in Master of Philosophy in Mathematics Education at Moi University. My research study is to find out the **INFLUENCE OF MATHEMATICAL SYMBOLS ON THE LEARNERS' PERFORMANCE IN KOIBATEK SECONDARY SCHOOLS, BARINGO COUNTY, KENYA.**

Any information given will be accorded an utmost confidentiality where possible.
Kindly allow me to carry out the research in your institution.

Yours Sincerely,

Kiprop C. Damaris

Reg. No.: EDU/ PGCM/1021/16

Appendix B: Learners' Questionnaire

Preamble

INFLUENCE OF MATHEMATICAL SYMBOLS ON THE LEARNERS' PERFORMANCE IN KOIBATEK SECONDARY SCHOOLS, BARINGO COUNTY, KENYA.

There is a guarantee that any information submitted will be treated with the utmost confidentiality and will only be used for academic purposes.

In this questionnaire, do not provide your name or even the name of your school.

SECTION A: Demographic information

1. What gender are you? Male ☐ Female ☐
2. To which of the following schools do you belong?

Private ☐ Public ☐

SECTION B

Influence of Mathematical Symbols on Students' Performance in Mathematics

Level of Agreement

Key: 1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree.

Key:	1	2	3	4	5
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree.					
My grasp of mathematical concepts is influenced by mathematical symbols					
Understanding the formulae and symbols used in today's textbooks					

Ability to convey word problems concisely and effectively with the use of relevant symbols.					
When I am unable to cope with certain symbols, I seek assistance.					
Student's ability to use relevant symbols to manipulate expressions and equations.					

Strategies used in teaching mathematics symbolic language and how they influence students' performance in mathematics

Key:	1	2	3	4	5
1 = Strongly Disagree; 2 = Disagree;					
3 = Neutral; 4 = Agree; 5 = Strongly Agree.					
Visual aids improve students' understanding of mathematical symbols.					
Teacher demonstrations on applying symbols enhance comprehension and problem-solving.					
Students' active involvement in demonstrations strengthens their understanding of symbols.					
Clear, logical demonstrations improve students' grasp of mathematical symbols.					
Introducing unfamiliar symbols in demonstrations boosts critical thinking and performance.					

Challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem solving procedures.

Key:

1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree.

Key:	1	2	3	4	5
1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree.					
There is poor attitude by students towards mathematics					
There is anxiety by students towards mathematics					
There is self-doubt towards mathematics by learners					
Students frequently rush through tasks involving mathematical symbols without careful consideration					
Students commonly misinterpret or misread mathematical symbols in problem statements.					

Appendix C: Interview Guide For Mathematics Teachers

1. Extend to which mathematical symbols influence students' performance in mathematics.
 - i) Do mathematics symbols influence students' understanding of mathematics concepts?.....
.....
 - ii) What difficulties do your students encounter when using mathematical symbols in solving mathematical problems?.....
.....
 - iii) Which are some of the mathematical symbols that are hindrances to your students when solving mathematical problems with symbols?.....
.....
.....
2. Strategies used in teaching mathematical symbols and how they influence students' performance in mathematics.
 - i) What specific strategies do you use when teaching mathematics content with symbols?.....
.....
 - ii) Do unfamiliar mathematical symbols in a concept or topic mark the point where students fail to understand the topic?.....
.....

- iii) If mathematics questions are wordy and not full of symbols, do your learners' performances become outstanding?.....

.....

3. Challenges that secondary school students encounter when interpreting and applying mathematical symbols in order to understand mathematical concepts and problem solving procedures.

- i) What are the challenges your students encounter when interpreting and using mathematical symbols?.....

.....

- ii) Sometimes students' own interpretation of mathematical symbols contradicts with its actual interpretation in English. Does this hamper students' progress in solving mathematical problems?.....

.....

- iii) Do students complete their maths activities quickly and with a thorough understanding of the features and symbols involved?.....

.....

Appendix D: Authorization Letter from Moi University



MOI UNIVERSITY

Office of the Dean School of Education

Tel: (053) 43001-8
(053) 43555
Fax: (053) 43555

P.O. Box 3900
Eldoret, Kenya

REF: EDU/PGCM/1021/16

DATE: 18th June, 2019

The Executive Secretary

National Council for Science and Technology
P.O. Box 30623-00100

NAIROBI

Dear Sir/Madam,

RE: RESEARCH PERMIT IN RESPECT OF KIPROP C. DAMARIS
- (EDU/PGCM/1021/16)

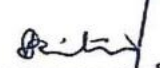
The above named is a 2nd year Master of Education (M.Ed) student at Moi University, School of Education, Department of Educational Management and Policy Studies.

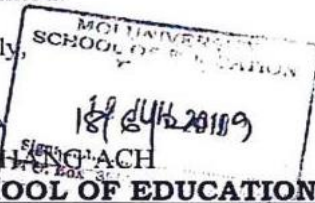
It is a requirement of her M.Ed Studies that she conducts research and produces a thesis. Her research is entitled:

"INFLUENCE OF MATHEMATICAL SYMBOLS ON THE LEARNERS' PERFORMANCE IN KOIBATEK SECONDARY SCHOOLS, BARINGO COUNTY, KENYA."

Any assistance given to enable her conduct research successfully will be highly appreciated.

Yours faithfully,


PROF. J. K. CHACHACH
DEAN, SCHOOL OF EDUCATION



(ISO 9001 – 2015 Certified Institution)

Appendix E: Research Permit

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 916866	Date of Issue: 05/August/2021
RESEARCH LICENSE	
	
This is to certify that Ms.KIPROP C. DAMARIS of Moi University, has been licensed to conduct research in Baringo of the topic: INFLUENCE OF MATHEMATICAL SYMBOLS ON THE LEARNERS' PERFORMANCE IN KOIBATEK SECONDARY SCHOOLS, BARINGO COUNTY, KENYA for the period ending : 05/September/2021.	
License No: EDU/PGCM/1021/1	
916868 Applicant Identification Number	 Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
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