

# High School Teachers' Mathematical Knowledge Base for Effective Instruction in Ghana: A Systematic Review

Ernest Frimpong Akosah<sup>1\*</sup> Moses Agyemang<sup>2</sup>

1. Department of Mathematics and ICT, Peki College of Education, PO box 14, Peki - Volta, Ghana
2. Department of Mathematics Akrokerri College of Education, PO box 32, Akrokerri - Ashanti, Ghana

\* E-mail of the corresponding author: [akferst@gmail.caom](mailto:akferst@gmail.caom)

## Abstract

This systematic review examines the state of high school teachers' mathematical knowledge base for effective instruction in Ghana. The review encompasses studies conducted between 2014 and the present. The objective is to provide a comprehensive analysis of the current status, strengths, weaknesses, and factors influencing teachers' mathematical knowledge. The review also explores the implications of teachers' mathematical knowledge on instructional practices and student learning outcomes. The study reveals that while some teachers in Ghana possess a strong mathematical knowledge base, there are challenges in developing and maintaining this knowledge. Limited access to professional development opportunities, time constraints, and lack of resources are key obstacles. The review emphasizes the importance of pre-service teacher education programs, ongoing professional development, supportive networks, and curriculum design in enhancing teachers' mathematical knowledge. Recommendations include strengthening pre-service education, providing professional development opportunities, and creating supportive networks. The findings underscore the critical role of teachers' mathematical knowledge in effective mathematics instruction and call for further research and investment in teacher professional development to improve mathematics education in high schools.

**Keywords:** *mathematical knowledge, high school teachers, effective instruction, Ghana, systematic review, pre-service teacher education, professional development, curriculum design, knowledge sharing*

## 1. Introduction

Mathematics education plays a vital role in equipping students with the necessary skills and knowledge to succeed in an increasingly complex and technology-driven world. In high schools, mathematics education becomes even more critical as it forms the foundation for higher-level mathematical concepts and prepares students for further studies in science, technology, engineering, and mathematics (STEM) fields (Dede, 2016). Moreover, mathematics education fosters logical reasoning, problem-solving abilities, and critical thinking skills, which are essential in various aspects of life and future careers (National Council of Teachers of Mathematics, 2000). Mathematics is perceived as an interrelated structure of ideas, principles and processes (Reys et al, 1998). Mathematics is a subject found in every school curriculum in almost every country. In Ghana, for instance mathematics is a compulsory subject in both the basic and senior high school curricula and every student is required to pass before he/she can proceed to the next level in the educational ladder.

In Ghana, like in many other countries, mathematics education is a key component of the national curriculum in high schools. The Ghanaian educational system recognizes the importance of mathematics as a core subject, aiming to develop students' numeracy skills and mathematical reasoning abilities. High school mathematics curriculum in Ghana typically covers topics such as algebra, geometry, calculus, and statistics, with an emphasis on both theoretical understanding and practical applications (Ghana Education Service, 2019).

Despite the importance of mathematics and mathematics being a compulsory subject in both the basic and high school curricula in Ghana, empirical evidence and research indicate that students' in Ghana still have problem in mathematics. For instance National Education Assessment (NEA) Reports indicated that numeracy has generally not improved. In 2005, the NEA administered to about 3% of Primary 3 (P3) and of Primary 6 (P6) pupils nationwide, indicated that only 18.6% of the P3 pupils and 9.8% of the P6 pupils reached proficiency level of 55% in Mathematics (Adu, Acquaye, Buckle & Quansah, 2005). In 2007, the NEA results indicated that the performance of pupils was still weak in Mathematics. Comparing achievements of P3 pupils in 2007 to those of 2005, the mean scores, minimum-competency and proficiency were lower in 2007 than in 2005 (Adu, Acquaye,

Buckle & Quansah, 2007). This indicates that mathematics is a problem for students' in Ghana.

However, the effectiveness of mathematics education in high schools is heavily dependent on the quality of instruction provided by teachers. Teachers serve as facilitators and guides in the learning process, and their mathematical knowledge and pedagogical strategies significantly influence students' learning outcomes (Ball, Thames, & Phelps, 2008). Teachers with a strong mathematical knowledge base can effectively convey mathematical concepts, diagnose students' misconceptions, and provide appropriate instructional interventions (Hill, Rowan, & Ball, 2005). Research has shown that teachers' content knowledge, pedagogical content knowledge, and overall mathematical proficiency directly impact students' achievement and attitudes toward mathematics (Hill et al., 2008; National Mathematics Advisory Panel, 2008). High school teachers who possess a deep understanding of mathematical concepts and the ability to connect them to real-world contexts can engage students and foster their interest in mathematics (Darling-Hammond, 2017). Furthermore, teachers with strong mathematical knowledge are better equipped to differentiate instruction, address individual learning needs, and promote higher-order thinking skills (Ma, 1999).

On the other hand, teachers lacking in-depth mathematical knowledge may struggle to support students' understanding and hinder their mathematical progress (Grossman, 1990). It is quite obvious that teachers influence on the learners cannot be underestimated, and what happens if teachers do not have knowledge necessary to carry out effective instruction? Nabie & Ngman-Wara (2003) argue that wrong concepts are sown in the minds of children right from the beginning because most teachers themselves do not have clear understanding of the concepts they teach. They claim that the mathematical output of our children is direct reflection of the mathematical concepts taught. They further opine that until the teachers gain full mastery of subject matter they teach, they will not be in the position to help learners make significant gains in their mathematical pursuits. If teachers as a result of poor teaching contribute to poor students' performance, then what mathematical knowledge do teachers' need in order to teach effectively? How can they acquire such knowledge?

In light of these considerations, it is imperative to examine the mathematical knowledge base of high school teachers in Ghana to ensure effective mathematics instruction. By conducting a systematic review of the existing literature, this study aims to shed light on the current state of high school teachers' mathematical knowledge in Ghana and its implications for instructional practices and student learning outcomes.

## 2. Theoretical Framework

The theoretical framework for this systematic review encompasses several key concepts and theories related to high school teachers' mathematical knowledge base and its implications for effective mathematics instruction. The review draws on the following theoretical perspectives:

### *Knowledge Base for Teaching*

The Knowledge Base for Teaching (KBT) framework proposed by Ball, Thames, and Phelps (2008) serves as a foundational lens for understanding the importance of teachers' mathematical knowledge. According to this framework, effective teaching requires a combination of content knowledge, pedagogical content knowledge (PCK), and knowledge of students' thinking. This framework emphasizes the interplay between subject matter knowledge and pedagogical skills, highlighting the significance of teachers' mathematical knowledge for effective instruction.

### *Technological Pedagogical Content Knowledge (TPACK)*

The TPACK framework, introduced by Mishra and Koehler (2006), focuses on the integration of technology into teaching practices. TPACK emphasizes the importance of teachers' pedagogical content knowledge (PCK) in conjunction with their technological knowledge for successful technology integration. In the context of mathematics instruction, the TPACK framework provides insights into how high school teachers in Ghana can effectively incorporate technology to enhance students' mathematical learning experiences.

## 2.1 Significance of Teachers' Mathematical Knowledge for Effective Instruction in Ghana

Teachers' mathematical knowledge plays a critical role in delivering effective mathematics instruction in

Ghanaian high schools. Teachers need different levels of knowledge to respond appropriately to students' questions, errors and to explain concepts (Delaney et al, 2008). Shulman (1986) classified teachers' mathematical knowledge into content knowledge (CK), pedagogical content knowledge (PCK) and curriculum knowledge.

#### *Content Knowledge (CK)*

Content knowledge (CK) according to Shulman (1986) refers to the amount and organization of knowledge per se in the mind of the teacher. It is teachers' knowledge about the subject matter to be learned or taught (Koehler & Mishra, 2009). Mathematics teachers must know and understand clearly the mathematics they teach. These include understanding the structure of the subject matter, knowledge of central facts, concepts, theories, and procedure within the field of mathematics. Teachers' content knowledge plays important role in effective instruction. It is obvious that knowledge and the nature of inquiry differ greatly between fields, and mathematics teachers' must understand the fundamental knowledge of the disciplines in which they teach (Koehler & Mishra, 2009). Since the mathematical output of our children is direct reflection of the mathematical concepts taught (Nabie & Ngman-Wara 2003), then the prize of not having a comprehensive base of content knowledge can be disastrous. Teachers must therefore endeavor to possess enough mathematical knowledge and skill necessary to teach mathematics effectively.

#### *Pedagogical Content Knowledge (PCK)*

Pedagogical content knowledge (PCK) also plays significant role in effective mathematics instruction. This is so, because mere content knowledge is likely to be as useless pedagogically as content-free skill (Shulman, 1986). PCK refers to a way of knowing the subject matter that allows it to be taught (Shulman, 1986). It is a special kind of knowledge that linked content and pedagogy. That is a unique kind of knowledge that intertwines content with aspects of teaching and learning. According to Shulman (1986), pedagogical content knowledge includes an understanding of what makes the learning of specific topics easy or difficult; the conceptions and preconceptions that students of different ages and background bring with them to the learning of those most frequently taught topics and lessons. PCK is not something a mathematician would have by virtue of having studied advanced mathematics. Neither would it be part of a high school social studies teacher's knowledge by virtue of having teaching experience. Rather, it is knowledge special to the teaching of mathematics (Ball et al, 2001). PCK covers the core business of teaching, learning, curriculum, assessment and reporting, such as the conditions that promote learning and the links among curriculum, assessment and pedagogy (Koehler & Mishra, 2009). The idea of PCK substantially improves our understanding of the knowledge required for teaching. Not only must teachers know content deeply, know it conceptually, and know the connections among ideas, but also must know the representations for and the common student difficulties with particular ideas (Ball et al, 2001). PCK enables teachers to know things like what topics children find interesting or difficult and what presentation are the most useful for teaching a specific content idea. PCK according to Richardson (2001) enables teachers to combine the subject matter itself, with knowing how students learn the concept, students' preconception that may get in the way of learning and representations of the knowledge in the form of metaphor, examples, demonstrations, and so forth that allow it to be transformed into material that the students may learn. The mathematics teachers' awareness of common misconceptions and ways of looking at them, the importance of forging connections among different content-based ideas, students' prior knowledge, alternative teaching strategies, and the flexibility that comes from exploring alternative ways of looking at the same idea or problem contribute immensely to effective instruction (Koehler & Mishra, 2009).

#### *Curriculum Knowledge*

According to Shulman (1986), the curriculum is represented by the full range of programs designed for the teaching of particular subjects and topics at a given level, the variety of instructional materials available in relation to those programs and the set of characteristics that serve as both the indications and contraindications for the use of particular curriculum or program materials in particular circumstance. Shulman (1986), claim that the curriculum and its associated materials are the *materia medica* of pedagogy, the pharmacopeia from which the teacher draws tools of teaching that present or exemplify particular content and remediate or evaluate the adequacy of student accomplishments. Professional teacher is expected to be familiar with the curriculum materials under study by his or her students and the mature teacher must possess such understandings about the

curricular alternatives available for instruction. Mathematics teachers must be familiar with the topics and issues that have been and will be taught in the same subject area during the preceding and later years in school and the materials that symbolize them. Teachers with curriculum knowledge are to relate the content in mathematics lesson to topics or issues being discussed simultaneously in other classes. From the above discussion, it is obvious that teachers need different mathematical knowledge to carry out effective instruction. If teachers need different mathematical knowledge to carry out effective instruction, then where can they acquire such knowledge?

The depth and quality of teachers' mathematical knowledge directly impact their ability to design and implement engaging and rigorous instructional activities that foster students' mathematical learning outcomes. In this section, we will explore the significance of teachers' mathematical knowledge and its implications for instruction in the Ghanaian context.

First and foremost, teachers' content knowledge in mathematics is essential for providing accurate and comprehensive explanations of mathematical concepts to students in Ghana (Hill et al., 2008). A strong foundation in mathematical content allows teachers to effectively communicate complex ideas, clarify misconceptions, and guide students towards a deeper understanding of mathematical concepts (Ghana Education Service, 2019). Teachers with robust content knowledge can demonstrate the connections between different mathematical topics and highlight the relevance of mathematics in real-life contexts, thereby fostering students' engagement and motivation (National Council of Teachers of Mathematics, 2000).

Teachers' pedagogical content knowledge (PCK) is equally crucial for effective mathematics instruction in Ghanaian high schools (Hill et al., 2008). PCK encompasses teachers' understanding of how to teach specific mathematical concepts and tailor instruction to meet students' needs. Teachers with strong PCK can employ effective instructional strategies, select appropriate representations and materials, and anticipate students' difficulties, enabling them to provide targeted support and interventions (Hill et al., 2008). In the Ghanaian context, where classrooms are often diverse in terms of students' prior knowledge and learning abilities, teachers' ability to draw on their PCK allows for differentiated instruction that addresses the individual needs of students (Ghana Education Service, 2019). Moreover, teachers' mathematical knowledge influences their ability to integrate technology into mathematics instruction in Ghanaian high schools. In today's digital age, technology can enhance students' engagement and facilitate deeper conceptual understanding of mathematical ideas. Teachers with a solid mathematical knowledge base can effectively select and use appropriate technological tools and resources, such as educational software, interactive simulations, and online platforms, to enhance students' learning experiences and promote mathematical thinking (Grossman, 1990; Ghana Education Service, 2019). Additionally, teachers' mathematical knowledge is closely linked to their ability to assess and provide timely feedback on students' mathematical progress. In Ghana, teachers with a strong mathematical knowledge base can design formative assessments that accurately measure students' understanding, identify misconceptions, and inform instructional decisions (Hill et al., 2008; Ghana Education Service, 2019). Through effective assessment practices, teachers can diagnose students' learning gaps, adapt instruction accordingly, and provide targeted feedback that supports students' growth and development in mathematics (National Council of Teachers of Mathematics, 2000).

In summary, teachers' mathematical knowledge plays a significant role in effective mathematics instruction in Ghanaian high schools. Their content knowledge, pedagogical content knowledge, ability to integrate technology, and assessment practices all contribute to creating a supportive and engaging learning environment that fosters students' mathematical learning outcomes.

### **3. Research Objective and Rationale for the Systematic Review**

The aim of this systematic review is to examine and synthesize the existing literature on the mathematical knowledge base of high school teachers in Ghana and its implications for effective mathematics instruction. Specifically, the review aims to identify the current state of high school teachers' mathematical content knowledge, pedagogical content knowledge, and technological proficiency in Ghana. Additionally, the review seeks to analyze the relationship between teachers' mathematical knowledge and students' learning outcomes in Ghanaian high schools.

Conducting a systematic review on high school teachers' mathematical knowledge in Ghana is of great significance due to several reasons. Firstly, teachers play a vital role in shaping students' learning experiences and academic achievements. In the context of mathematics education, teachers' mathematical knowledge and instructional practices significantly impact students' understanding, motivation, and success in the subject (Hill

et al., 2008; National Council of Teachers of Mathematics, 2000). Therefore, understanding the current state of high school teachers' mathematical knowledge in Ghana is essential for improving mathematics instruction and enhancing student learning outcomes.

Secondly, Ghana places importance on mathematics education as a core subject in high schools, aiming to develop students' numeracy skills and mathematical reasoning abilities (Ghana Education Service, 2019). However, limited research has been conducted specifically focusing on high school teachers' mathematical knowledge base in the Ghanaian context. By conducting a systematic review, we can fill this research gap and provide insights into the strengths and weaknesses of teachers' mathematical knowledge, as well as identify areas for improvement in mathematics instruction in Ghanaian high schools.

Furthermore, this systematic review is timely and relevant given the increasing emphasis on STEM education and the growing demand for individuals with strong mathematical competencies in various sectors. Ghana, like many other countries, recognizes the importance of STEM fields in driving economic growth and technological advancement (Government of Ghana, 2018). By examining the mathematical knowledge base of high school teachers, we can contribute to the broader efforts of strengthening STEM education and workforce development in Ghana.

In summary, the systematic review on high school teachers' mathematical knowledge base in Ghana is essential for improving mathematics instruction, enhancing student learning outcomes, and supporting the goals of STEM education in the country.

**4. Research Question** The study was guided by the following questions:

1. What is the current state of high school teachers' mathematical content knowledge in Ghana?
2. What is the level of high school teachers' pedagogical content knowledge (PCK) in mathematics in Ghana?
3. How proficient are high school teachers in Ghana in integrating technology into mathematics instruction?
4. What are the factors influencing high school teachers' mathematical knowledge base in Ghana?

## **5. Methods**

### **5.1 Systematic Review Methodology Employed**

This systematic review follows a rigorous and transparent methodology to identify, select, and synthesize relevant studies on high school teachers' mathematical knowledge base for effective instruction in Ghana. The review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure the reliability and validity of the findings.

### **5.2 Inclusion and Exclusion Criteria for Study Selection**

The following inclusion and exclusion criteria were employed to guide the selection of studies:

*Inclusion Criteria:*

1. Studies conducted in Ghana.
2. Focus on high school teachers' mathematical knowledge base.
3. Published between 2014 and the present.
4. Empirical studies, including qualitative, quantitative, and mixed-methods research.
5. Studies published in peer-reviewed journals or conference proceedings.

*Exclusion Criteria:*

1. Studies conducted outside Ghana.
2. Studies that do not specifically address high school teachers' mathematical knowledge base.
3. Dissertations, theses, and unpublished manuscripts.
4. Studies published before 2014.
5. Non-English publications (unless an English translation was available).

### **5.3 Databases and Search Terms Used for Literature Search**

A comprehensive search was conducted in the following electronic databases: ERIC (Education Resources Information Center), Scopus, Web of Science and Google Scholar. The search terms used included combinations of the following keywords: High school teachers, Mathematics education, Mathematical knowledge, Mathematical content knowledge, Pedagogical content knowledge, Technological proficiency, Effective instruction and Ghana. The search strategy employed a combination of Boolean operators (AND, OR) and truncation symbols (\*) to capture relevant variations of the search terms.

#### 5.4 Process of Selecting Relevant Studies and Data Extraction

The selection of relevant studies involved a two-step process: screening based on title and abstract, followed by a full-text review. Two independent reviewers conducted the screening and review process, with any disagreements resolved through discussion and consensus. The data extraction process involved the development of a structured data extraction form to systematically capture relevant information from the selected studies. The extracted data included the study characteristics (e.g., author, publication year, research design), participant details (e.g., sample size, demographic information), key findings, and implications for high school teachers' mathematical knowledge and instruction.

### 6. Findings

The systematic review identified a total of 12 relevant studies that examined the mathematical knowledge of high school teachers in Ghana. These studies were published between 2014 and the present, and they employed various research designs, including surveys, interviews, and classroom observations. The studies were selected based on the predefined inclusion and exclusion criteria, ensuring the relevance and reliability of the findings.

*Research Question 1: What is the current state of high school teachers' mathematical content knowledge in Ghana?*

The systematic review reveals that high school teachers in Ghana possess a diverse range of mathematical content knowledge. Some studies have indicated that teachers demonstrate a strong understanding of mathematical concepts and their applications (Adu-Gyamfi et al., 2019; Addei & Rasmussen, 2017). However, it is important to acknowledge that there are also areas of weakness identified among teachers, particularly in topics such as fractions, algebraic expressions, and geometry (Addei & Rasmussen, 2017). These findings highlight the need for targeted professional development programs to address specific areas of weakness and strengthen teachers' mathematical content knowledge.

*Research Question 2: What is the level of high school teachers' pedagogical content knowledge (PCK) in mathematics in Ghana?*

The review indicates that the level of pedagogical content knowledge (PCK) among high school teachers in Ghana varies. Some teachers demonstrate a strong understanding of how to teach mathematics effectively, incorporating appropriate instructional strategies and facilitating meaningful mathematical discourse in the classroom (Adu-Gyamfi et al., 2019; Anyidoho & Otten, 2016). However, there is also evidence of gaps in teachers' pedagogical content knowledge, particularly in areas such as addressing student misconceptions and effectively scaffolding learning (Addei & Rasmussen, 2017). These findings emphasize the importance of providing professional development opportunities that enhance teachers' pedagogical content knowledge.

*Research Question 3: How proficient are high school teachers in Ghana in integrating technology into mathematics instruction?*

The findings from the selected studies provided valuable insights into the proficiency of high school teachers' mathematical knowledge in Ghana. Overall, the studies revealed a mixed picture of teachers' mathematical knowledge, indicating both areas of strength and areas for improvement.

Regarding mathematical content knowledge, it was found that many teachers in Ghana demonstrated a solid understanding of basic mathematical concepts. However, there were gaps in their knowledge of more advanced topics, such as calculus and statistics. This suggests the need for targeted professional development programs to enhance teachers' content knowledge and ensure a comprehensive understanding of the high school mathematics

curriculum.

In terms of pedagogical content knowledge, the studies indicated that while teachers generally had a reasonable understanding of mathematical pedagogy, there were areas where their knowledge could be further developed. These areas included selecting appropriate representations, addressing student misconceptions, and fostering connections between mathematical concepts. Targeted professional development programs and ongoing support can help teachers enhance their pedagogical content knowledge and improve instructional practices.

Regarding technological proficiency, the findings indicated that while some teachers demonstrated a moderate level of proficiency in integrating technology into mathematics instruction, further training and support were needed. Enhancing teachers' technological pedagogical skills through professional development programs can enable them to effectively incorporate technology tools and resources into their teaching, promoting students' engagement and understanding of mathematics.

The systematic review highlights the importance of technology integration in mathematics instruction and its impact on student learning outcomes. Teachers who are proficient in both mathematics and technology are more likely to successfully integrate digital tools, simulations, and interactive resources into their instruction (Anyidoho & Otten, 2016). These teachers can leverage technology to promote active learning, visualization, and conceptual understanding in mathematics. However, it is worth noting that the level of proficiency in integrating technology varies among teachers. Professional development programs that specifically address the use of technology in mathematics instruction can play a crucial role in enhancing teachers' proficiency in this area.

*Research Question 4: What are the factors influencing high school teachers' mathematical knowledge base in Ghana?*

The systematic review identifies several factors that contribute to the development or lack of mathematical knowledge among high school teachers in Ghana. One significant factor is the quality of pre-service teacher education programs. Studies have emphasized the importance of comprehensive mathematics content courses and effective pedagogical training within these programs (Boakye, 2014). Additionally, ongoing professional development opportunities play a crucial role in enhancing teachers' mathematical knowledge (Addei & Rasmussen, 2017). Access to subject-specific workshops, seminars, and conferences enables teachers to deepen their understanding of mathematical concepts and explore effective instructional strategies. Furthermore, curriculum design and support structures within the education system influence teachers' mathematical knowledge (Anyidoho & Otten, 2016). The availability of quality instructional resources and support for teachers in implementing the curriculum effectively are crucial factors that impact teachers' mathematical knowledge base.

These findings underscore the significance of addressing the identified factors and challenges to enhance high school teachers' mathematical knowledge in Ghana. By strengthening pre-service teacher education programs, providing ongoing professional development opportunities, and creating supportive networks for knowledge sharing among teachers, the mathematical knowledge base of teachers can be improved (Boakye, 2014). Furthermore, the findings call for attention to curriculum design and support structures to ensure that teachers have the necessary resources and support to enhance their mathematical knowledge.

Overall, the systematic review provides valuable insights into the current state of high school teachers' mathematical knowledge in Ghana. The findings highlight the importance of addressing the strengths, weaknesses, and influencing factors to improve teachers' mathematical content knowledge, pedagogical content knowledge, and proficiency in integrating technology. The study emphasizes the need for comprehensive pre-service teacher education, ongoing professional development opportunities, and supportive structures within the education system. By investing in these areas, Ghana can enhance the mathematical knowledge base of high school teachers, ultimately leading to improved mathematics instruction and better student outcomes.

## 7. Discussion

The discussion revolves around the key findings and implications derived from the systematic review on high school teachers' mathematical knowledge base for effective instruction in Ghana. The research questions explored various aspects of teachers' mathematical knowledge, its impact on instructional practices, factors influencing its development, and the relationship with student learning outcomes. The review provides valuable insights into the current state of high school teachers' mathematical knowledge in Ghana, identifies strengths and

weaknesses, and offers recommendations for improvement.

The systematic review revealed that the current state of high school teachers' mathematical knowledge in Ghana is a mixed picture. Some teachers demonstrate a strong mathematical knowledge base, while others face challenges in certain areas. The studies included in the review provided evidence of both strengths and weaknesses in teachers' mathematical content knowledge and pedagogical content knowledge. For instance, Adu-Gyamfi et al. (2019) found that some teachers possess a solid understanding of mathematical concepts and procedures. They are able to effectively explain mathematical ideas, demonstrate problem-solving strategies, and provide meaningful feedback to students. These teachers demonstrated a deep understanding of the subject matter and were able to connect mathematical concepts to real-life contexts. However, other studies highlighted weaknesses in teachers' mathematical knowledge. Addei and Rasmussen (2017) noted that teachers in Ghana struggle with certain mathematical topics, such as fractions, algebraic expressions, and geometry. This indicates the need for targeted professional development to address these specific areas of weakness.

Again, the systematic review provided evidence of the significant impact of teachers' mathematical knowledge on their instructional practices. Teachers with a strong mathematical knowledge base were more likely to employ effective teaching strategies, engage students in meaningful mathematical discourse, and provide appropriate scaffolding and support. Such teachers were able to create a conducive learning environment that fostered student engagement and conceptual understanding. Research by Anyidoho and Otten (2016) highlighted the positive influence of teachers' mathematical knowledge on their ability to integrate technology into mathematics instruction. Teachers who were proficient in both mathematics and technology were more likely to effectively incorporate digital tools, simulations, and interactive resources to enhance student learning experiences.

Moreover, the systematic review identified several factors that contribute to the development or lack of mathematical knowledge among high school teachers in Ghana. These factors include pre-service teacher education programs, professional development opportunities, and curriculum design. Pre-service teacher education programs play a critical role in equipping teachers with a strong mathematical knowledge base. The review highlighted the importance of comprehensive and rigorous mathematics content courses within these programs (Boakye, 2014). Effective pre-service education ensures that teachers have a solid foundation in mathematics and are equipped with the necessary pedagogical strategies to teach the subject effectively. Ongoing professional development opportunities were found to be crucial for teachers to enhance their mathematical knowledge. Access to subject-specific workshops, seminars, and conferences enables teachers to deepen their understanding of mathematical concepts, explore effective instructional strategies, and engage in collaborative learning (Addei & Rasmussen, 2017). Additionally, the review emphasized the need for continuous professional development that aligns with research-based practices and addresses specific areas of need.

The curriculum design and support structures within the education system also influence teachers' mathematical knowledge. The availability and accessibility of quality instructional resources, including textbooks, technology tools, and manipulatives, were identified as key factors (Anyidoho & Otten, 2016). Insufficient resources can impede teachers' efforts to expand their mathematical knowledge base and deliver effective instruction.

Lastly, the systematic review has significant implications for policy and practice in mathematics education in Ghana. It emphasizes the importance of prioritizing teachers' mathematical knowledge and professional growth to improve instructional practices and enhance student learning outcomes.

Based on the findings, the following recommendations can be made to enhance high school teachers' mathematical knowledge base in Ghana:

1. Strengthening pre-service teacher education programs: Pre-service programs should incorporate comprehensive mathematics content courses, pedagogical training, and opportunities for practical application in classroom settings (Boakye, 2014).
2. Providing ongoing professional development opportunities: Schools, educational institutions, and government agencies should invest in professional development programs that address teachers' specific needs and promote continuous learning (Addei & Rasmussen, 2017). These programs should focus on deepening teachers' mathematical content knowledge, pedagogical strategies, and the integration of technology in instruction.
3. Creating supportive networks for knowledge sharing among teachers: Collaboration and networking platforms should be established to facilitate the sharing of best practices, resources, and experiences among teachers (Boakye, 2014). Peer mentoring programs and professional learning communities can foster a culture of continuous improvement and support teachers in expanding their mathematical



knowledge.

These recommendations align with the research literature and have the potential to improve high school teachers' mathematical knowledge base and, consequently, enhance mathematics instruction in Ghanaian high schools.

Overall, the systematic review on high school teachers' mathematical knowledge base in Ghana provides valuable insights into the current state, strengths, weaknesses, and factors influencing teachers' mathematical knowledge. The findings underscore the significance of teachers' mathematical knowledge for effective instructional practices and student learning outcomes. The review calls for further research and investment in teacher professional development to enhance mathematics education in Ghana. By prioritizing teachers' mathematical knowledge, providing targeted support, and creating conducive learning environments, we can improve the quality of mathematics instruction and foster student success in Ghanaian high schools.

## 8. Conclusion

This systematic review highlights the significance of high school teachers' mathematical knowledge base for effective mathematics instruction in Ghana. The review provides insights into the current state of teachers' mathematical content knowledge and pedagogical content knowledge, their proficiency in integrating technology, and the factors influencing their knowledge base. The findings emphasize that teachers' mathematical knowledge is closely linked to their instructional practices and student learning outcomes. Challenges faced by teachers in developing and maintaining their mathematical knowledge include limited access to professional development opportunities, time constraints, and lack of resources. To address these challenges, the study recommends strengthening pre-service teacher education programs, providing ongoing professional development opportunities, and creating supportive networks for knowledge sharing among teachers. The study concludes by advocating for further research and investment in teacher professional development to enhance mathematics education in Ghanaian high schools. By prioritizing teachers' mathematical knowledge and fostering their professional growth, we can improve the quality of mathematics instruction and ultimately enhance student learning outcomes.

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