

Short thesis

Development of knowledge and skills in initial mathematics teacher education and early years of teaching career in Ghanaian Basic Schools

Introduction

Achieving Sustainable Development Goal 4.6 (SDG) predicts that, by 2030, all young people and a significant proportion of adults, regardless of gender, will attain proficiency in literacy and numeracy (UNESCO, 2021), this and the other 16 SDGs have become the hallmark of most educational systems. The integration of SDG 4.6 into educational systems worldwide has driven significant curriculum reforms, emphasising the importance of inclusive and equitable quality education. Schools are now adopting innovative teaching methods and ensuring that learning environments are safe and supportive for all students. This approach addresses learners' diverse needs and creates pathways for lifelong learning and personal development. In Ghana, the basic school curriculum has been undergoing several restructuring. The 2019 Ghanaian curriculum sought to establish a practical, relevant, and inclusive education system, arming learners with the essential skills and knowledge for personal growth while contributing to Ghana's development. The pre-tertiary education programme aimed to align with the Global Proficiency Framework and global best practices, prioritising skills like critical thinking and fostering skills development. This is a substantial departure from conventional educational approaches to equip learners for the demands of the contemporary world (MoE, 2019). Similarly, the provision of accessible and quality education for all to meet the country's needs is the core of the basic school curriculum; based on this, the new curriculum clearly outlines the learning areas to be taught, along with the methods of teaching and assessment. It also establishes core competencies and standards that students are expected to know, understand, and demonstrate as they advance through the curriculum (MoE, 2019). Many studies are concerned with the mathematical content knowledge of pre-service teachers (e.g., Depaepe et al., 2013; Mapolelo & Akinsola, 2015, Wu et al., 2018).

The Gap in Knowledge

According to studies by Eshun (2004) and Eshun-Famiyeh (2005), mathematics is seen as the most challenging subject in the school curriculum in Ghana. This general view has mirrored in students' performance over time. The National Education Assessment (NEA) administered from 2015 to 2022 showed that school-going children in Ghana struggled to read. Also, their performance in mathematics lagged the expected grade, with the percentages of basic three (3) and basic six (6) learners achieving proficiency in mathematics falling below 20 % (Fletcher, 2018; Hagan et al., 2020). Again, according to the Early-Grade Literacy and Mathematics Assessment (EGLMA) findings, only 6 % of primary school learners met the required benchmark for numeracy in Ghana (MoE, 2019).

Improving the teaching and learning of mathematics in Ghana has been an object of national interest for some time now (Aboagye & Yawson, 2020). In response to this demand, researchers, educators, and other stakeholders in the education sectors have channeled research into the issue and the way forward (e.g., Asiedu et al., 2004; Kraft, 1994; Mereku, 2004). Based on these empirical research and recommendations, the new mathematics curriculum for basic schools and Colleges of Education was introduced in 2019. Although several researchers (e.g., Eshun, 2004; Eshun-Famiyeh, 2005; Mereku, 2004; MoE, 2017) have explored mathematics classroom practices at the primary and senior secondary levels, not much work has been done on developing knowledge and skills in initial mathematics teacher education at the early-grade level.

Study Purpose and Research Questions

Several researchers (e.g., Eshun, 2004; Eshun-Famiyeh, 2005; Mereku, 2003) have explored mathematics classroom practices at the primary and senior secondary levels. However, not much work has focused specifically on early-grade teacher education. Therefore, the present study aimed to fill this gap by addressing several specific research questions (RQs).

RQ1: What alignments exist between the early-grade mathematics curriculum implemented by Colleges of Education in Ghana and the National Kindergarten Mathematics Curriculum?

The findings of research question have been accepted for publication in (Amusuglo, Jančařík, 2024a).

RQ2: How do Ghana's national kindergarten and Colleges of Education early-grade mathematics curricula align with the knowledge and skills outlined by the Global Proficiency Framework?

The result of Research Question 2 has been published in Amusuglo & Jančařík (2024).

RQ3: What are pre-service and early career teachers' attitudes toward mathematics in Ghana?

The findings of research question 3 have been accepted for publication in Amusuglo et al., (2024).

RQ4: How do pre-service and in-service teachers' attitudes towards mathematics relate to their mathematics teaching efficacy beliefs?

RQ5: What content and pedagogical content knowledge do early career teachers and pre-service early-grade teachers possess at the end of their College Education?

The findings of this have been published in Amusuglo (2024).

Related Literature

Assessing teachers' knowledge base has been a challenging task due to various interpretations provided by researchers (e.g., Ball & Bass, 2000; Cochran & Jones, 1998; Grossman & Richert, 1988; Hill et al., 2008, Leinhardt & Smith, 1985; Ma, 1999; Shulman, 1986; Tamir, 1990; Thompson, 1984). Shulman (1986) introduced a model outlining seven types of teacher knowledge: general pedagogical knowledge, knowledge of student characteristics, educational contexts, purposes and values, content knowledge, curriculum knowledge, and pedagogical content knowledge (PCK). Later, he focused on three key areas: subject matter knowledge (SMK), PCK, and curriculum knowledge. According to Shulman, subject matter knowledge is the "amount and organisation of the knowledge per se in the teacher's mind" (Shulman, 1986, p. 9). Pedagogical content knowledge involves "ways of representing the subject which make it comprehensible to others" ...[it] also includes an understanding of what makes the learning of specific topics easy or difficult ..." (Shulman, 1986, p. 9).

Knowledge of the curriculum includes understanding how topics are organised throughout the school year and other techniques for setting up a study plan for students using educational resources like textbooks. Even though Shulman's categories are not specific to mathematics teaching, many mathematics educators have used them as a foundation for their study. Similarly, Grossman and Richert (1988) characterise teacher knowledge as "a professional knowledge base encompassing both general pedagogical principles and skills, as well as subject matter expertise" (p. 54). Their study explored the essential knowledge for teaching, defining *teacher knowledge* as a blend of pedagogical principles and subject matter expertise. It highlights the importance of pedagogical content knowledge (Shulman, 1986), noting that teaching experience prompts teachers to reassess subject matter from students' perspectives. This shift underscores the necessity for teacher education programmes to incorporate opportunities for teachers to deepen their understanding of subject matter about student learning, emphasising the critical role of pedagogical content knowledge. Thompson (1984) also suggested that teachers' use of mathematical knowledge in teaching might be influenced by their personal beliefs and perspectives regarding the subject. Researchers agree that teaching effectiveness is influenced not only by teachers' knowledge but also by their attitudes, beliefs, and self-efficacy (Chan & Elliot, 2004). Han and Carpenter (2014) define attitude as a combination of cognitive, affective, and behavioural responses that individuals exhibit towards an object or environment based on their feelings or interests.

Methodology

Data for this study were collected using three methods: content or document analysis, survey questionnaires administered to pre-service early-grade teachers and in-service teachers in the early years of their teaching careers, and interviews conducted with both categories of teachers.

Content or document analysis was employed to address (RQ1) and 2 (RQ2), focusing on a qualitative examination of relevant materials. To answer (RQ3) and 4 (RQ4), quantitative methods were used, specifically the ATMI (Attitudes Toward Mathematics Inventory) and MTEBI (Mathematics Teaching Efficacy Beliefs Instrument) questionnaires.

These instruments are standardised and widely recognised for assessing teachers' attitudes and efficacy beliefs related to mathematics teaching. Finally, a mixed-methods approach was applied to analyse (RQ5), integrating both qualitative and quantitative data to provide a comprehensive understanding of the issue.

Summary of Findings

RQ1: What alignments exist between the early-grade mathematics curriculum implemented by Colleges of Education in Ghana and the National Kindergarten Mathematics Curriculum?

The analysis revealed that the content of the Ghanaian National KG Mathematics Curriculum aligns closely with the B.Ed. Early Grade Mathematics Curriculum. Both curricula cover similar mathematical topics, including numbers, algebra, geometry, measurement, and data handling, and incorporate key pedagogical strategies such as problem-solving, scaffolding, and play-based learning. The problem-solving approach emphasises conceptual understanding through engagement with complex, real-world problems. Scaffolding supports learners with varying abilities, ensuring inclusivity, while play-based learning is a central feature of the KG curriculum but is less detailed in the B.Ed. Curriculum.

The play-based activities are not embedded in the B.Ed. Early Grade Mathematics Curriculum. It is recommended that the Kindergarten (KG) Mathematics Curriculum be integrated into the B.Ed. Curriculum to equip pre-service teachers with practical, developmentally appropriate teaching methods for early-grade mathematics.

RQ2: Global Proficiency Framework: Analysis of National and Colleges of Education Curricula in Ghana.

The study identified a close alignment between Ghana's early-grade mathematics curriculum, the Colleges of Education curricula, and the Global Proficiency Framework (GPF). The national curriculum adheres to global standards by addressing key domains like numbers, algebra, and geometry. The Ghanaian curriculum introduces fractions in Grade 1, whereas the GPF introduces fractions in Grade 3. This proactive inclusion in the Ghanaian curriculum may help students build a deeper understanding of mathematical concepts at an earlier stage additionally, the B.Ed. The curriculum emphasises pedagogical strategies designed to equip teachers with the skills needed for

effective mathematics instruction, further highlighting its compatibility with global expectations. This alignment suggests that the curricula support students in achieving proficiency benchmarks comparable to international standards.

RQ3: What are pre-service and early career teachers' attitudes toward mathematics in Ghana?

The study seeks to understand the attitudes of pre-service and early career teachers toward mathematics, which can significantly impact their teaching practices and effectiveness. It explores factors influencing these attitudes, such as their experiences in mathematics education, perceptions of mathematics, and their confidence in teaching the subject.

The study's results reveal that both pre-service and in-service teachers generally have positive attitudes towards mathematics, showing agreement across areas like enjoyment, self-confidence, value, and expectations from parents and teachers. Pre-service teachers, still in training, displayed a slightly higher level of enjoyment in mathematics, which aligns with the idea that enjoyment is linked to positive emotional experiences in engaging with math.

A more significant gap was observed in the self-confidence dimension, with pre-service teachers showing higher confidence levels than in-service teachers. This difference may be due to pre-service teachers' limited experience with challenges in the field and their recent training in educational theories and methodologies, which boosts their confidence. Despite this gap, both groups expressed overall confidence in their math abilities, supporting the notion that self-confidence is linked to greater motivation and success in mathematics.

Pre-service teachers also placed slightly more importance on the value and relevance of mathematics in their professional lives and problem-solving skills. This higher valuation could be due to their recent exposure to educational approaches that emphasise the role of math in developing critical thinking. This finding aligns with the idea that perceiving mathematics as valuable encourages greater engagement and the ability to connect mathematical concepts with real-world applications.

RQ4: How do pre-service and in-service teachers' attitudes towards mathematics relate to their mathematics teaching efficacy beliefs?

This question explores how the attitudes of pre-service and in-service teachers toward mathematics are related to their beliefs about their efficacy in teaching the subject. The study is framed by two key hypotheses:

There will be a statistically significant relationship between pre-service and in-service teachers' attitudes toward mathematics and their teaching efficacy beliefs.

This hypothesis is rooted in the understanding that teachers' attitudes toward mathematics can influence how they perceive their ability to effectively teach the subject. For pre-service teachers, their beliefs about their teaching efficacy are likely to be shaped by the experiences they gain throughout their teacher education programs. These experiences include coursework, classroom observations, teaching practice, and personal interactions with mathematics during their education. The more positive their experiences with the subject, the more likely they are to develop a belief in their ability to teach it effectively.

On the other hand, in-service teachers develop their teaching efficacy beliefs through hands-on teaching experiences in real classroom settings. Their beliefs are influenced by factors such as the challenges they face in the classroom, their ongoing professional development, and feedback from students and colleagues. As teachers engage with the realities of classroom teaching, their attitudes toward mathematics may also be influenced by student outcomes, the success or challenges they face in lesson delivery, and the professional support they receive. Despite the differences in their contexts, both pre-service and in-service teachers are expected to share a common trend: those with a more positive attitude toward mathematics will likely report stronger beliefs in their ability to teach mathematics effectively. Therefore, it is anticipated that teachers in both groups, whether still in training or actively teaching, will demonstrate a clear relationship between their attitudes toward mathematics and their teaching efficacy beliefs.

There will be no statistically significant difference in the attitudes toward mathematics when comparing pre-service and in-service teachers.

This second hypothesis assumes that, while teaching experience may provide new insights and strategies for teaching, the fundamental attitudes toward mathematics are

largely shaped by personal and educational factors that are stable over time. Both pre-service and in-service teachers are believed to carry core perspectives toward the subject formed during their own schooling, intrinsic interest in mathematics, and their broader cultural and educational contexts. Pre-service teachers, who are in the midst of formal teacher training, often bring their prior experiences with mathematics from their school years, which may influence their initial attitudes toward the subject. These teachers are also likely to be in a phase of developing their identity as educators, which may make their attitudes more malleable and closely tied to their educational environment.

Similarly, in-service teachers, though they have more practical experience, are still influenced by their initial experiences with mathematics. While their professional practice and classroom challenges may influence their perspectives, these factors are not expected to drastically alter their foundational attitudes toward the subject. It is believed that both groups' attitudes are more strongly shaped by their personal dispositions, early educational experiences, and the cultural or societal values surrounding mathematics. The stability of these attitudes over time suggests that, despite the experience gap, the general perspectives on mathematics may remain relatively similar between pre-service and in-service teachers. Consequently, it is expected that the attitudes toward mathematics of both pre-service and in-service teachers will not differ significantly, as these attitudes are deeply rooted in personal and educational experiences that remain consistent, regardless of professional status.

RQ5: What content knowledge and pedagogical content knowledge do early career teachers and pre-service early-grade teachers possess at the end of their college education?

This research question investigates the depth and breadth of both Content Knowledge (CK) and Pedagogical Content Knowledge (PCK) that pre-service and early career teachers have acquired by the time they complete their college education. The focus is on understanding how well-prepared these teachers are to effectively teach mathematics at the early-grade levels in Ghanaian Basic Schools. The study on Pedagogical Content Knowledge among early career and pre-service early-grade mathematics teachers used a mixed-method approach to explore the development and challenges of PCK. The quantitative analysis revealed that both groups have an average level of PCK, but pre-

service teachers showed a higher level than early career teachers. This finding suggests that recent exposure to modern teaching methods during training gives pre-service teachers an advantage despite early career teachers having more classroom experience.

The qualitative phase identified themes such as initial PCK development, factors influencing growth, challenges faced, strategies for improvement, and the role of support systems. It was found that early career teachers initially focused on procedural teaching methods but shifted towards more conceptual approaches as they gained experience. Classroom experience and reflective practices were crucial in enhancing PCK, supporting the idea that hands-on teaching is vital for growth.

Challenges highlighted included resource limitations, time constraints, and large class sizes, which hindered the ability to adopt student-centred teaching methods. Despite these barriers, teachers were committed to improving their PCK by integrating real-world applications into lessons and adopting more learner-centred strategies. Teachers emphasised the need for better access to resources, technology, and continuous professional development.

A key limitation of the study was its small sample size, as it was conducted in only two districts with participants from four schools. Expanding the sample could provide a broader perspective and more generalizable results. Nonetheless, the findings align with existing research on PCK and the challenges in mathematics education

Discussion

This study explores key aspects of early-grade mathematics education, focusing on the alignment of pre-service teacher education programmes with the Ghanaian National Kindergarten (KG) Mathematics Curriculum, teachers' attitudes toward mathematics, and their impact on teaching efficacy. It also examines the levels of content knowledge (CK) and pedagogical content knowledge (PCK) among pre-service and early-career teachers. The findings provide insights into critical areas affecting the preparedness and effectiveness of mathematics teachers, highlighting both strengths and areas for improvement in teacher education and practice.

The study highlights a discrepancy between pre-service teacher education programmes and the Ghanaian National KG Mathematics Curriculum. Misalignment can hinder teachers' readiness to deliver effective mathematics instruction, potentially impacting

the quality of education in early-grade classrooms by failing to equip them with the necessary instructional strategies and knowledge required for effective early mathematics teaching. Furthermore, the findings demonstrate that positive attitudes toward mathematics significantly influence teaching practices. Teachers with positive attitudes exhibit higher confidence and perceived teaching efficacy, creating more engaging and supportive learning environments. However, some participants expressed anxiety about their content knowledge and pedagogical strategies, suggesting that even generally positive attitudes toward mathematics may coexist with concerns about their ability to effectively teach the subject.

Teachers' attitudes toward mathematics directly affect their beliefs about teaching efficacy. Positive attitudes enhance teachers' confidence and ability to implement effective teaching practices, ultimately contributing to improved student mathematics outcomes. Finally, both pre-service and early-career teachers possess varying levels of CK and PCK. However, gaps remain in these areas, potentially limiting their ability to deliver effective and innovative mathematics instruction.

Conclusion

In conclusion, this study underscores the importance of aligning pre-service teacher education programmes with the Ghanaian National Kindergarten Mathematics Curriculum to ensure that teachers are well-prepared to deliver high-quality early-grade mathematics instruction. It highlights the significant role of teachers' attitudes toward mathematics in shaping their teaching efficacy and overall teaching practices. While positive attitudes can enhance confidence and teaching effectiveness, concerns about content knowledge and pedagogical strategies remain. The study also reveals that although both pre-service and early-career teachers demonstrate varying levels of content and pedagogical content knowledge, there are still critical gaps that need to be addressed to improve instructional quality. Ultimately, addressing these gaps and enhancing the alignment between teacher education and curriculum will be crucial for fostering effective early mathematics education and ensuring that teachers are adequately equipped to meet the challenges of the classroom.

Recommendations

Strengthening mathematics education in early grades requires a robust foundation in teacher preparation and support. The findings of this study underline critical areas for improvement, including the alignment of pre-service education with the Ghanaian National Kindergarten (KG) Mathematics Curriculum, addressing teacher anxiety about mathematics, fostering positive attitudes toward the subject, and bridging gaps in both content knowledge (CK) and pedagogical content knowledge (PCK). To ensure teachers are adequately prepared to deliver effective mathematics instruction, targeted recommendations are essential to address these challenges and improve the quality of early-grade mathematics education.

One key recommendation is to enhance the alignment between pre-service teacher education programmes and the Ghanaian National KG Mathematics Curriculum. Integrating the KG curriculum into teacher training programmes would ensure that pre-service teachers are equipped with the knowledge and skills required to meet the expectations of the national curriculum. This integration would better prepare teachers to handle classroom realities and ensure a seamless transition from training to practice, ultimately improving instructional effectiveness and student outcomes.

Addressing teachers' anxiety about mathematics is another crucial area for intervention. The study found that some teachers expressed anxiety about their subject knowledge despite generally positive attitudes toward mathematics. Professional development initiatives should focus on reducing this anxiety by offering targeted training and support. Workshops and refresher courses could strengthen teachers' mathematical understanding, boost their confidence, and help them overcome any apprehensions related to teaching the subject.

Promoting positive attitudes toward mathematics is equally important. Teacher education programmes should include strategies to cultivate enthusiasm for the subject, such as integrating enjoyable, real-world problem-solving tasks and encouraging reflective practices. By fostering a positive mindset, teachers can inspire similar attitudes in their students, creating a more engaging and supportive learning environment. Teachers with positive attitudes are not only more confident but also more likely to adopt innovative and effective teaching practices.

Content knowledge (CK) and pedagogical content knowledge (PCK) are vital for ensuring that teachers are well-prepared to deliver quality mathematics instruction. Colleges of Education should incorporate more comprehensive content and pedagogical training, emphasising practice-oriented courses and mentorship programmes. Providing access to classroom-based experiences during training would allow pre-service teachers to refine their instructional strategies and gain hands-on experience applying theoretical knowledge to real teaching contexts.

Furthermore, ongoing support for in-service teachers is essential for their continued growth and effectiveness. Continuous professional development opportunities should address challenges such as managing large classes and implementing learner-centred approaches. These programmes should enhance CK and PCK, enabling teachers to adapt to diverse classroom needs and maintain high-quality instruction throughout their careers.

In conclusion, these recommendations aim to address the key challenges identified in this study, fostering a stronger foundation for mathematics education in Ghanaian early-grade classrooms. By aligning teacher training with curriculum goals, addressing anxiety, promoting positive attitudes, and bridging knowledge gaps, these measures will ensure that teachers are better equipped to inspire and support young learners in their mathematical journey.

Limitations of the Study

One key limitation of this study was the relatively small sample size. The research was conducted in only two of the 170 districts in the country, with participants drawn from just four out of 102 basic schools in the two regions. While the sampling technique helped to maximise variation within the study sample, including additional districts would have allowed for a larger participant pool, providing a more representative view and enabling broader generalisation to a larger population. Despite this limitation, several findings from this study align with those of other researchers (e.g., Lakens, 2022). Another limitation of this study is the absence of classroom observations, which would have provided direct insights into teachers' application of Pedagogical Content Knowledge (PCK) in real-world instructional settings. Observing classroom practices could have revealed how teachers integrate their subject matter knowledge and pedagogy to address students' needs, manage misconceptions, and employ instructional

strategies effectively. This would have offered a practical perspective on how teacher beliefs and efficacy translate into classroom actions, complementing the quantitative findings. Without this observational data, the study is limited in its ability to explore the practical manifestations of PCK, mainly how it interacts with teachers' attitudes and efficacy beliefs.

Qualitative data collection and analysis, such as interviews or focus groups, could have been included to provide deeper insights into the factors influencing these constructs. The absence of qualitative data limits the ability to capture nuanced perspectives and contextual influences that quantitative methods alone may not reveal.

Implication of the Findings

The findings of this study suggest substantial implications for improving the knowledge and skills necessary for initial mathematics teacher education and the early teaching experiences in Ghanaian Basic Schools.

Firstly, the higher PCK scores among pre-service teachers suggest that current teacher education programmes in Ghana effectively provide a strong theoretical foundation. However, the challenges reported by early career teachers indicate a need to bridge the gap between theory and practice. Teacher education programmes should incorporate more practical, classroom-based experiences to prepare teachers for the realities of Ghanaian classrooms.

Secondly, the identified challenges, particularly resource constraints and large class sizes, highlight the need for systemic support in Ghanaian education. Policymakers should prioritise providing adequate resources and addressing infrastructure issues to enable teachers to implement effective teaching strategies.

Thirdly, the importance of ongoing professional development and peer support suggests a need for structured mentoring programmes and regular in-service training opportunities in Ghanaian schools. These should focus on enhancing PCK, particularly in learner-centred approaches and integrating real-world applications in mathematics teaching.

Lastly, the expressed need for technological resources indicates an area for potential investment to support teachers' PCK development and enhance mathematics instruction in Ghanaian Basic Schools.

This research aimed to investigate how early-grade mathematics teachers develop knowledge and skills during their initial teacher education and early teaching years, with the goal of informing strategies to enhance the quality of mathematics education in Ghana. Through the methodological approach and data analysis, this research successfully achieved its aim of understanding the development of knowledge and skills among early-grade mathematics teachers in Ghana. There have been some suggested practical strategies to enhance the quality of mathematics education, contributing to improved learners' performance in mathematics in Ghanaian schools. Educational stakeholders can cultivate competent and confident mathematics educators by addressing the identified factors and implementing the suggested strategies.

In conclusion, this research has made a valuable contribution to mathematics education, particularly within the Ghanaian context, offering important insights for educators and stakeholders in the educational sector. The findings highlight issues for both teachers and policymakers, although teachers are aware of the new curriculum guidelines, there is a need for more professional development sessions that take into account the mathematics knowledge of both pre-service and in-service early-grade teachers. Organising these sessions will ensure that these guidelines are fully integrated into classroom practices. Taking these steps will enhance the quality of mathematics education and help achieve the curriculum's objectives in the classroom.

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