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Foundational Mathematical Knowledge as a Determinant of Senior Secondary School Performance in Nigeria: A Conceptual and Theoretical Synthesis

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Abstract

This study investigated the role of foundational mathematical knowledge as determinant of senior secondary school mathematics performance in Nigeria. Existing literature reveals a number of predictors of mathematics performance, but little attention has been given to the cumulative and structural influence of foundational mathematical competencies within a unified conceptual and theoretical framework. Drawing on constructivist theory, prior knowledge theory, cognitive load theory and spiral curriculum theory, this study develops a conceptual model for explaining the effect of foundational mathematical knowledge on mathematics performance across the educational progression. The model identifies cognitive readiness and classroom engagement as key mediators and instructional quality and learning environment as moderators that influence mathematics performance. The study identifies systemic limitations in the Nigerian educational context to include discontinuities in curriculum, poor diagnostic assessment practices, inadequate emphasis on conceptual understanding, and a continued reliance on procedural teaching approaches. The study proposes a reconceptualization of mathematics performance as a cumulative developmental process based on foundational competencies and presents a framework for future empirical testing. The synthesis highlights among others the need for strengthening foundational mathematical instruction, promoting conceptually focused pedagogical practices, strengthening teacher professional development in foundational mathematical pedagogy, encouraging curriculum alignment across educational levels, and incorporating foundational mathematical competencies into educational intervention policies. The discussion explores implications for instructional practice, curriculum development, educational policy, and future research.

Keywords: Foundational knowledge, Mathematics performance, Cognitive load, Conceptual framework, Nigeria.

Introduction

Mathematics is a school subject that is characterized by accuracy, abstraction, and logical reasoning, and is essential for the advancement of science and technology while cultivating critical thinking and problem-solving abilities that are vital for the development of both individuals and society (Cresswell & Speelman, 2020; Yadav, 2019). Mathematics is vital for day-to-day living. It is essential to the daily operations of housewives, traders, laypeople, artists, musicians, financiers, economists, chemists, physicians, scientists, technicians, engineers, and technologists. Any country that advances in mathematics will also advance economically, scientifically, and technologically (Zalmon & Charles-Ogan, 2020). Therefore, it is necessary to focus on mathematics education at all educational levels. Because of its significance to scientific and technological development, mathematics is studied as a compulsory subject at the primary and secondary school levels of education in Nigeria (Nigerian Educational Research and Development Council [NERDC], 2013; Federal Republic of Nigeria [FRN], 2014).

In spite of the importance of mathematics, in Nigeria however, senior secondary school students' performance in this crucial subject has continuously been subpar, especially in high-stake examinations such as the West African Senior School Certificate Examination (WASSCE) and the National Examinations Council (NECO) examinations (WAEC, 2023; NECO, 2023). Popoola and Olarewaju (2010), Udonsa (2015), and Awofala and Fatade (2023) also revealed at different periods that students' performance in mathematics in Nigeria have consistently remained unsatisfactory. The situation is quite disheartening, considering the government's effort to improve mathematics instruction. This continued underperformance remains a concern for educators, policy makers and researchers. Existing literature has attributed poor performance in mathematics to several factors such as; ineffective instructional practices, teacher quality, socio-economic constraints, and student-related variables such as anxiety and negative attitudes (Aremu & Sokan, 2003; Asikhia, 2010). While these factors are important, there is relatively limited conceptual attention given to the structural role of foundational knowledge acquired at earlier stages of schooling.

The learning of mathematics is hierarchical and cumulative, where advanced concepts are built upon previously acquired knowledge and skills (Kilpatrick et al., 2001). Students at the senior secondary school level who did not master foundational mathematical concepts such as arithmetic operations, fractions, ratios, and early algebraic thinking are more likely to have difficulties in learning advanced topics such as trigonometry, calculus, and statistics (National Mathematics Advisory Panel [NMAP], 2008; Siegler et al., 2012). As a result, such deficiencies may accumulate overtime, resulting in persistent misconceptions, increased cognitive load, and ultimately lower academic performance.

In the Nigerian educational system, the issue has been worsened by various problems such as overcrowded classrooms, limited instructional time, inadequate teaching resources, poor teaching methods, and limited use of diagnostic assessment practices (Adeniyi & Awofala, 2023; Aremu & Sokan, 2003; Ogunniyi, 2011). Consequently, many students journey through the educational system without having mastery of basic mathematical concepts, thus weakening the basic knowledge needed for higher learning. It is on this note that this study provides a conceptual re-examination of the relevance of foundational knowledge in the mathematics performance of senior secondary school students in Nigeria. Specifically, the study aims to:

1. Explain the concept of foundational knowledge in mathematics education;
2. Examine the theoretical foundations of its role in learning;
3. Review the existing literature on foundational knowledge and mathematics performance;
4. Develop a conceptual framework that connects foundational knowledge with performance;
5. Discuss implications for practice, policy, and future research.

This study aims to achieve these objectives and contribute to the ongoing discourse on how to improve mathematics education outcomes in Nigeria.

Definition of Concepts

Foundational mathematical Knowledge

Foundational mathematical knowledge refers to the basic mathematical concepts, skills, procedures, and understandings acquired during early learning experiences that form the basis for further mathematical development (National Research Council [NRC], 2001; Kilpatrick et al., 2001). These foundational elements make up the cognitive and conceptual base upon which higher mathematics ideas are constructed. In mathematics education, foundational knowledge does not just serve a preparatory function, but is also essential for enabling continuity, coherence and progression in learning. Key components of foundational mathematical knowledge include basic arithmetic operations (addition, subtraction, multiplication, and division); fractions, decimals and percentages; ratios, proportions, and rates; elementary algebra, measurement, geometry, and data handling (Clements & Sarama, 2009; NRC, 2001; NMAP, 2008; NERDC, 2013).

Foundational mathematical knowledge also comprises more general cognitive competencies such as number sense, which involves flexibility in thinking about numbers, estimation skills, and the ability to see relationships among numbers (Siegler & Lortie-Forgues, 2014). Number sense has been shown to be a powerful predictor of later success in algebra and higher-level mathematics (Jordan et al., 2009; Siegler & Lortie-Forgues, 2014). Foundational knowledge is not only procedural competency but also conceptual understanding, which is defined as understanding of mathematics concepts, operations, and relations (Hiebert & Lefevre, 1986). According to Hiebert and Lefevre (1986) and Kilpatrick et al. (2001), conceptual understanding enables students to connect mathematical ideas, explain procedures, and apply knowledge in unfamiliar situations. Consequently, weak conceptual foundations established during earlier stages of schooling may limit students' ability to engage successfully in higher-order mathematical reasoning and problem-solving at the senior secondary school level (Kilpatrick et al., 2001; NMAP, 2008). On the other hand, the use of procedural knowledge alone typically leads to learning that is fragmented, easily forgotten, and difficult to transfer (Rittle-Johnson et al., 2001).

A key feature of foundational knowledge is that it enables the transfer of knowledge and cumulative learning. Mathematics is hierarchical by nature, meaning that new knowledge is built on what has been learnt before (Kilpatrick et al., 2001). When fundamental concepts are not well understood, students are likely to develop misconceptions that are persistent and hinder later learning (NMAP, 2008). For example, poor understanding of fractions has been linked to difficulties in algebra and proportional reasoning (Siegler et al., 2012). Furthermore, foundational knowledge is essential for the development of mathematical proficiency, which includes conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (Kilpatrick et al., 2001). Students who possess strong foundational mathematical knowledge are more likely to engage in meaningful problem-solving, demonstrate flexibility of thought, retain knowledge over time, and apply mathematical concepts effectively in real-life situations (Kilpatrick et al., 2001; Gashaj et al., 2023; Spitzer et al., 2024).

Foundational knowledge is often seen as a strong predictor of future performance in mathematics (Balt et al., 2020). Empirical and meta-analytic evidence consistently suggests that foundational competencies and prior knowledge are strongly associated with subsequent learning and mathematics performance (Dochy et al., 1999; Gashaj et al., 2023; Siegler et al., 2012; Spitzer et al., 2024). Thus, foundational mathematical knowledge could be a prerequisite to learning and at the same time, a major determinant of students' performance in mathematics at higher levels of education.

However, evidence from Nigeria indicates that many learners progress through the basic education system without attaining adequate mastery of foundational mathematical skills and numeracy competencies required for higher-level mathematics learning (Zalmon & Charles-Ogan, 2020; Universal Basic Education Commission [UBEC] & United Nations Children's Fund [UNICEF], 2025). Several factors have been identified in the Nigerian mathematics education literature that could hinder the development of a strong mathematics understanding, such as overcrowded classrooms, inadequate instructional support, limited opportunities for conceptual engagement, and overreliance on rote learning methods (Awofala et al., 2022; Ogunniyi, 2011). These limitations could lead to learning gaps that accumulate through the educational levels, which could impede students from successfully coping with the advanced mathematics concepts encountered at the senior secondary school level.

Senior Secondary Mathematics Performance

Senior secondary mathematics performance refers to students' level of achievement in mathematics at the upper secondary level of education. It is commonly reflected in students' mastery of mathematical knowledge, skills, reasoning, problem-solving abilities, and application of mathematical concepts as demonstrated through classroom and standardized assessments (National Council of Teachers of Mathematics [NCTM], 2000; FRN, 2014). At the senior secondary school level in Nigeria, performance is commonly assessed through standardized examinations such as the West African Senior School Certificate Examination (WASSCE) and the National Examinations Council (NECO) examinations, as well as through continuous assessment activities including classroom tests, assignments, and projects (FRN, 2014). Mathematics performance may also be reflected in students' ability to solve problems, reason mathematically, and apply mathematical concepts to real-life situations (NCTM, 2000).

Mathematics performance is a multidimensional construct that extends beyond the ability to produce correct answers. It encompasses conceptual understanding, procedural fluency, strategic competence, mathematical reasoning, and the capacity to communicate and apply mathematical knowledge effectively in diverse contexts (Kilpatrick et al., 2001; NCTM, 2000; Organization for Economic Co-operation and Development [OECD], 2023). Research has shown that performance in mathematics is affected by a complex set of cognitive, affective, instructional and environmental factors (Ma, 1999). Cognitive factors such as prior knowledge, intelligence and metacognitive skills, and affective factors such as attitudes to mathematics, motivation and anxiety

(Ashcraft & Krause, 2007). Instructional factors are associated with teaching methods, teacher competence and classroom practices while environmental factors include school resources, class size and socio-economic background (Aremu & Sokan, 2003). At the senior secondary school level, mathematics becomes more abstract and demands higher-order thinking skills, such as reasoning, generalizing and problem-solving (Hiebert et al., 2003). Topics such as algebra, trigonometry, calculus, and statistics require a solid understanding of previously acquired mathematical concepts because mathematics learning is cumulative and hierarchical in nature (Kilpatrick et al., 2001; NMAP, 2008). Consequently, students who lack strong foundational mathematical knowledge often experience difficulties in understanding more advanced concepts, which may ultimately contribute to poor academic performance in mathematics (NMAP, 2008; Siegler et al., 2012).

Empirical evidence consistently indicates that prior mathematics performance is a strong predictor of subsequent performance (Duncan et al., 2007; Watts et al., 2014; Siegler et al., 2012). Students who progress to higher levels of education with deficiencies in foundational mathematical knowledge often experience difficulties in learning advanced concepts, exhibit lower academic self-confidence, and develop negative attitudes toward mathematics (Duncan et al., 2007; Claessens & Engel, 2013; Siegler et al., 2012; Zalmon & Charles-Ogan, 2020). The examination reports of WAEC and NECO have consistently revealed poor performance in senior secondary school mathematics in Nigeria, with a substantial proportion of candidates failing to obtain credit-level passes required for further education and employment opportunities (NECO, 2022, 2023; WAEC, 2022, 2023). This trend has been partly attributed by scholars to poor foundational preparation in earlier stages of education, as deficiencies in early mathematics knowledge often persist and hinder subsequent learning (Kilpatrick et al., 2001; Siegler et al., 2012). This underscores the need to re-conceptualize mathematics performance not merely as an outcome of senior secondary instruction, but as the cumulative result of learning experiences across the educational continuum.

Theoretical Framework

This study integrates four learning theories to explain the role of foundational knowledge:

1. **Constructivist Theory (Piaget, 1970; Vygotsky, 1978):** Learning builds on previous knowledge; weak foundations lead to misconceptions.
2. **Prior Knowledge Theory (Ausubel, 1968):** The effectiveness of new learning is dependent on prior knowledge.
3. **Cognitive Load Theory (Sweller, 1988):** Strong foundational knowledge reduces cognitive overload and enhances learning efficiency.
4. **Spiral Curriculum Theory (Bruner, 1960):** Learning progresses through repeated reinforcement of previous concepts.

In general, these theories stress the cumulative nature of learning mathematics, and the importance of having a strong foundation for meaningful understanding and development.

Theoretical Synthesis

These theories, taken together, suggest a shared core insight: the importance of foundational knowledge for learning mathematics effectively. In constructivist theory it is emphasized as important for knowledge construction, in prior knowledge theory it is highlighted as important for meaningful learning, in cognitive load theory its necessity for cognitive efficiency is accounted for, and in spiral curriculum theory its role in cumulative progression is emphasized. Collectively, they imply that foundational knowledge influences the interpretation and acquisition of new knowledge, weak foundations lead to cognitive overload, misconceptions and poor performance, and that strong foundations lead to conceptual understanding, problem-solving and long-term retention.

This theoretical synthesis provides a solid justification for the necessity of foundational knowledge in mathematics education, particularly in light of students' persistent underperformance.

Review of Related Literature

Foundational Knowledge and Mathematics Performance

Empirical studies have demonstrated that early mathematics competence is a strong predictor of later academic performance (Duncan et al., 2007; Gashaj et al., 2023; Watts et al., 2014). Early mathematics skills are one of the strongest predictors of future academic success, even stronger than early literacy skills (Duncan et al., 2007). Similarly, Jordan et al. (2009) found that number sense and early numeracy skills were significant predictors of later mathematics performance, especially in areas such as algebra and problem solving. Additional research has demonstrated that mathematics learning is cumulative, and that gaps in foundational knowledge are likely to persist and grow over time if no intervention is provided (Siegler et al., 2012). Understanding foundational skills such as fractions, ratios, and basic arithmetic operations is particularly important because these competencies underpin students' ability to learn algebra, trigonometry, calculus, and other advanced mathematical concepts encountered at higher levels of education (NMAP, 2008; Siegler et al., 2012).

Research has shown the effect of foundational gaps on students' performance in mathematics. It has been revealed that poor understanding of fundamental mathematical concepts significantly impedes students' performance in algebra and related areas of mathematics (NMAP, 2008; Siegler et al., 2012). Similarly, Kilpatrick et al. (2001) and Siegler et al. (2012) asserted that lack of foundational mathematical knowledge has been found to significantly hinder students' later performance, especially in areas such as algebra and problem-solving. The results indicate that many of the learning difficulties experienced at the senior secondary level are rooted in poor mastery of earlier concepts, highlighting the need to give priority to foundational learning.

Mathematics Anxiety and Deficits in Foundational Concepts

Research suggests that weaknesses in foundational mathematical competencies can contribute to the development of mathematics anxiety, creating a cycle in which poor mathematical understanding leads to anxiety, which in turn further impairs mathematical performance (Carey et al., 2016; Dowker et al., 2016). Mathematics anxiety is strongly related to poor foundational knowledge. Students who lack basic understanding of mathematics concepts often experience repeated failures in mathematics tasks, leading to frustration, lower confidence, and negative attitudes toward the subject (Ashcraft & Krause, 2007). These experiences accumulate over time and lead to mathematics anxiety, a psychological condition that involves tension and apprehension when confronted with mathematics tasks. Research has revealed that mathematics anxiety impairs working memory which in turn reduces the ability of students to effectively process and solve mathematics problems (Ashcraft & Krause, 2007). This sets up a vicious cycle. Weak foundational knowledge leads to anxiety, anxiety leads to reduced cognitive efficiency, and reduced cognitive efficiency leads to poor performance. In this respect, foundational deficits are not just cognitive impediments but also affective constraints that hinder the overall mathematics development of students.

Instructional Practices and Foundational Learning

Instructional practices are central to the development of foundational knowledge. Research has shown that conventional approaches to teaching based primarily on rote memorization and procedural drills are generally ineffective in promoting deep conceptual understanding, as students often learn procedures without understanding the underlying mathematical relationships and concepts (Hiebert & Carpenter, 1992; Hiebert & Grouws, 2007; NCTM, 2000; Ogunniyi, 2011). Such approaches may allow students to do routine calculations but may not provide students with the understanding of applying knowledge in new or complex situations. However, studies have shown that learner-centred instructional approaches, including inquiry-based learning, problem-based learning, and the use of multiple representations, are more effective in fostering conceptual understanding, mathematical reasoning, and durable foundational knowledge than traditional teacher-oriented methods (Bruner, 1961; Hmelo-Silver, 2004; Hiebert & Grouws, 2007; NCTM, 2000; Rittle-Johnson et al., 2015). These approaches foster active engagement, critical thinking, and meaningful learning, which are crucial for the long-term retention and transfer of knowledge. However, the Nigerian educational system is characterized by the dominance of teacher-centred methods, which are partly due to large class sizes and examination pressures, which continue to limit opportunities for meaningful learning (Ogunniyi, 2011). This instructional gap contributes to the weak foundational knowledge that students have which in turn affects their performance at higher levels.

Curriculum and Transition Challenges

The transition from Junior Secondary School (JSS) to Senior Secondary School (SSS) is a critical stage in students' mathematics development. The senior secondary school mathematics curriculum is structured on the assumption that learners have mastered the foundational concepts and skills introduced during primary and junior secondary education (NERDC, 2012; FRN, 2014). However, evidence suggests that many students transition to senior secondary education without adequate preparation in prerequisite mathematical knowledge, thereby experiencing

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difficulties with more advanced mathematical concepts (Bruner, 1960; NCTM, 2000; Duncan et al., 2007; Siegler et al., 2012; Zalmon & Charles-Ogan, 2020). A major learning challenge is the mismatch between curriculum expectations and students' capabilities. Students who do not possess a strong foundation find it difficult to cope with the increased abstraction and complexity of senior secondary mathematics and this results in poor performance and disengagement (Kilpatrick et al., 2001).

In Africa, systemic constraints, particularly in under-resourced education systems, continue to hamper effective foundational learning (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2020; World Bank, 2018). In Nigeria, the situation is further compounded by curriculum implementation challenges such as inadequate instructional time, overcrowded classrooms and limited use of formative assessment (Ogunniyi, 2011). Consequently, the foundational gaps are not filled and students are promoted to higher levels without the required level of mastery. This underscores the need for greater alignment of curricula, pedagogy and assessment systems to ensure that foundational knowledge is developed sufficiently before progressing.

Research Gap

Although there is a large body of research in the area of mathematics performance, the existing literature has largely focused on instructional approaches, learner characteristics, teacher-related factors, and environmental influences, with relatively less focus on foundational mathematical knowledge as a key determinant of academic performance. Previous studies have highlighted the importance of instructional practices in mathematics education, which indicate that instructional interventions and pedagogical strategies can enhance students' mathematics performance (Omolafe & Okikiayo, 2023; Opesemowo et al., 2025). In addition, some empirical studies have been conducted to investigate variables such as teacher qualification and professional competence (Jekayinfa et al., 2022), attitude towards mathematics (Awofala, 2020), classroom engagement, mathematics anxiety, learning environments and instructional practices that influence mathematics performance (Byiringiro, 2023; Egara & Mosimege, 2024; Malik & Rizvi, 2018). These studies provide useful information on factors related to mathematics performance, but these variables are often examined in isolation and do not adequately capture the role of foundational mathematical competencies acquired through earlier learning experiences in later mathematics performance. Mathematics learning is cumulative and hierarchical. This means that the lack of foundational mathematical competencies gained during the earlier stages of learning could significantly impede students' ability to understand and apply more advanced mathematical concepts at the senior secondary school level (Kilpatrick et al., 2001; NMAP, 2008; Siegler et al., 2012).

Despite the growing recognition of the importance of prior knowledge and foundational competencies in learning processes and later academic success (Balansag et al., 2025; Gashaj et al., 2023; Spitzer et al., 2024), there remains a dearth of conceptual synthesis that combines theoretical perspectives and empirical evidence to account for the role of foundational mathematical knowledge on students' academic performance in Nigeria. The literature also demonstrates a lack of theoretical integration that connects foundational mathematical knowledge to more general explanatory frameworks such as constructivist learning theory, schema theory and cumulative learning perspectives.

Hence, there is need for a conceptual and theoretical synthesis in order to consolidate existing evidence, integrate relevant theoretical perspectives and provide a more coherent explanation of foundational mathematical knowledge as a determinant of senior secondary school performance in Nigeria. The present study seeks to address this gap by synthesizing theoretical insights and empirical evidence towards a clearer conceptual explanation of the role of foundational mathematical knowledge as a determinant of mathematics performance of senior secondary school students.

Conceptual Framework

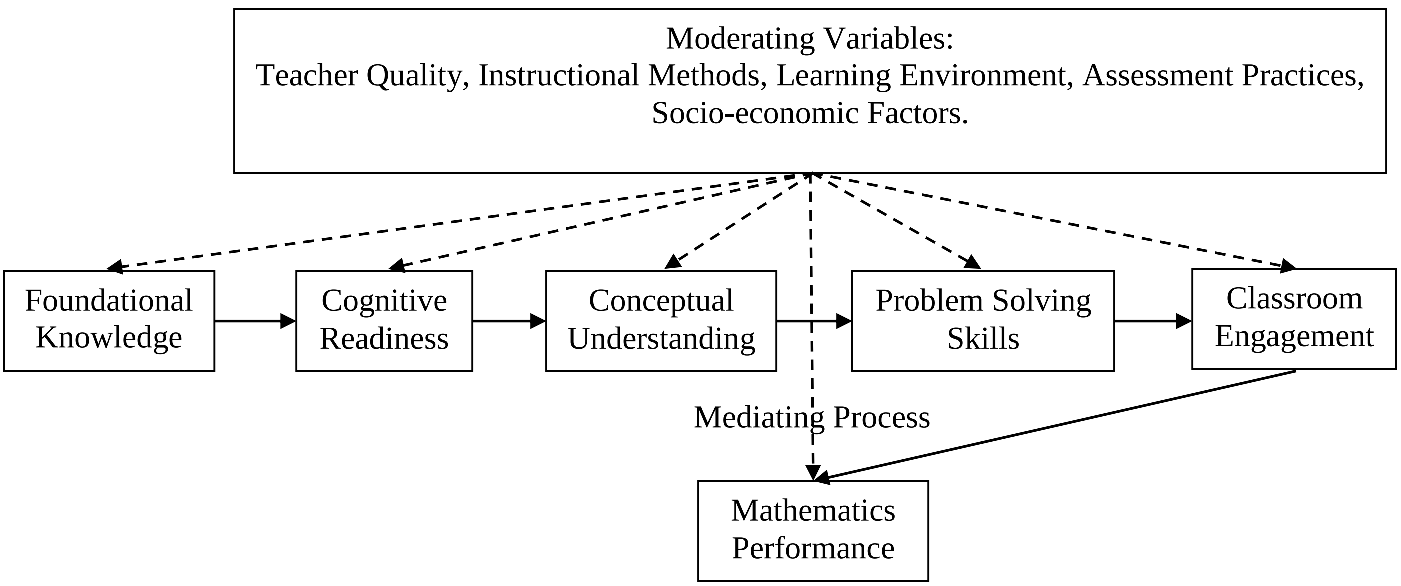
Building on the theoretical perspectives and empirical evidence reviewed, this study puts forward a conceptual framework that outlines the pathways through which foundational knowledge affects senior secondary school mathematics performance. The framework is based on the assumption that the learning of mathematics is cumulative and hierarchical in the sense that what is learned earlier has a strong effect on what is learned later (Kilpatrick et al., 2001). Therefore, foundational knowledge is seen as the primary input variable that influences learners' readiness to engage in advanced mathematics concepts.

The framework proposes a sequential pathway as follows:

Foundational Knowledge → Cognitive Readiness → Conceptual Understanding → Problem- Solving Skills → Classroom Engagement → Mathematics Performance

Figure 1 illustrates this conceptual framework, highlighting both the sequential relationships among the fundamental variables and the moderating role of contextual factors like teacher quality, instructional methods, learning environment, assessment practices, and socio-economic factors.

Figure 1:
Conceptual framework illustrating the pathways through which foundational mathematical knowledge influences senior secondary school mathematics performance, with moderating effects of contextual factors.



The proposed framework views mathematics performance as a progressive and interdependent process where each stage builds on the previous one. It begins with foundational knowledge, including learners' prior knowledge of basic mathematics concepts such as number sense, arithmetic operations, and elementary algebra. This knowledge is the cognitive basis upon which further learning depends. Having a strong foundation allows students to process new information better and that leads to cognitive readiness, which is the mental readiness to engage with more complex and abstract mathematics ideas. This cognitive readiness, in turn, leads to development of conceptual understanding, where learners move beyond rote memorization to understanding relationships among mathematics concepts. At this point, students are able to describe ideas, make connections, and interpret mathematics representations in meaningful ways.

Conceptual understanding develops problem-solving skills and enables learners to apply appropriate strategies to routine and non-routine mathematics problems. Students gain confidence and interest in mathematics as they develop problem-solving skills, which leads to greater engagement in the classroom. Engaged students are more likely to be active participants, persevere through challenges and invest effort in learning activities. Over time, continued classroom engagement leads to improved mathematics performance, as evidenced by students' success in assessments and their ability to use mathematics knowledge in real-life situations. The relationships in the framework are also moderated by variables such as teacher quality, instructional methods, learning environment, assessment practices and socioeconomic factors. These variables influence each and every stage of the learning process directly influencing the extent to which foundational knowledge is successfully converted into higher order cognitive skills, engagement and performance outcomes.

In general, the framework highlights that mathematics performance is not an isolated outcome, but the result of a sequential and reinforcing chain of cognitive and behavioural processes based on the strength of foundational knowledge and shaped by contextual conditions.

Discussion

The analysis in this study underlines the importance of foundational knowledge in the learning of mathematics. Consistent with constructivist and cognitive theories, mathematics is cumulative in nature, and deficiencies at early stages tend to propagate and intensify over time (Kilpatrick et al., 2001; Sweller, 1988). This is the reason many students find it difficult to cope with the senior secondary level where the mathematics content becomes more abstract and more demanding cognitively. The problem is compounded by systemic challenges in the Nigerian context such as heavy dependence on teacher-centered instructional practices, poor use of formative assessment and overcrowded classrooms (Ogunniyi, 2011). These conditions often limit the opportunities for meaningful learning and limit the development of strong foundational knowledge.

The interplay between cognitive and affective factors is also discussed. Students who have weak foundational knowledge are more likely to experience repeated failures which results in decreased self-efficacy, disengagement, and mathematics anxiety (Ashcraft & Krause, 2007). This creates a reinforcing cycle where poor understanding leads to low engagement, which in turn further reduces performance. The implications of these findings are that improving mathematics performance requires a paradigm shift from content coverage to mastery-oriented learning. The emphasis should be on ensuring that students acquire a strong knowledge of the fundamental concepts before moving on to the advanced ones. Without addressing foundational deficits, interventions at the senior secondary level are unlikely to produce significant or sustainable improvements in learning outcomes.

Implications

Implications for Teachers

Teachers play a critical role in shaping students' foundational knowledge. There is a need to:

i. Focus on understanding concepts rather than rote memorization.
ii. Employ diagnostic and formative assessments to pinpoint learning gaps at an early stage.
iii. Provide targeted remediation and differentiated instruction to support struggling learners.
iv. Use multiple representations and real-life examples to enhance understanding.

Implications for Curriculum Developers

Curriculum design should facilitate the development of foundational knowledge in a progressive way by:

i. Ensuring vertical alignment across primary, junior secondary, and senior secondary school levels.
ii. Incorporating structured reinforcement and remediation strategies into the curriculum.
iii. Reducing content overload to provide adequate time for mastery of key concepts.
iv. Focusing on core competencies such as reasoning, problem solving and conceptual understanding.

Implications for Policymakers

Policy interventions need to be made at the system level to strengthen foundational learning by:

i. Ensuring quality basic education as the foundation for all subsequent learning.
ii. Investing in teacher professional development especially in mathematics pedagogy.
iii. Encouraging evidence-based teaching practices and continuous assessment systems.
iv. Improving learning conditions, such as class size and availability of instructional materials.

Implications for Researchers

This conceptual framework provides the basis for further empirical research. Future research should:

i. Perform quantitative and mixed method studies to validate proposed relationships.

ii. Examine the relative influence of mediating and moderating variables.
iii. Explore intervention strategies to build foundational knowledge.
iv. Highlight context-specific studies in Nigeria to inform policy and practice.

Conclusion

This study examined the role of foundational knowledge in senior secondary school mathematics performance in Nigeria from a conceptual perspective. It has argued that a key determinant of students' ability to understand, engage with and succeed at advanced mathematics is foundational knowledge. Based on the existing learning theories and empirical studies, this study constructed a conceptual model that explains the cognitive and behavioural mechanisms of the effect of foundational knowledge on mathematics performance. The analysis shows that continuous poor performance in mathematics cannot be fully addressed without tackling the underlying issue of weak foundational knowledge. Hence, improving foundational learning at the basic education level is key to improving outcomes at the senior secondary school level.

Ultimately, improving mathematics education in Nigeria requires concerted effort of teachers, curriculum developers, policymakers and researchers. By prioritizing foundational knowledge and adopting evidence-based practices, it is possible to promote meaningful learning, improve academic performance, and contribute to national development goals in general.

Recommendations

Based on the conceptual and theoretical synthesis presented in this study, the following recommendations are suggested:

1. **Strengthen the teaching of foundational mathematical at the basic education level:** Educational stakeholders should focus on developing foundational mathematical competencies in primary and junior secondary education. Greater instructional emphasis should be placed on number sense, arithmetic fluency, fractions, proportional reasoning, introductory algebra, and conceptual understanding, as these competencies constitute crucial foundations for later mathematics learning.
2. **Promote teaching approaches emphasizing conceptual understanding:** Mathematics instruction should focus on teaching for conceptual understanding, reasoning, and problem solving rather than teaching procedures. Teachers are urged to use learner-centred teaching strategies that help students apply their knowledge flexibly in a variety of circumstances and make meaningful connections between mathematical concepts.
3. **Use diagnostic assessment practices:** Schools need to use diagnostic assessment practices throughout the learning process to identify gaps in students' foundational mathematical knowledge prior to moving to more advanced concepts. Early identification of misconceptions can reduce the cumulative learning difficulties that may lead to poor mathematics performance.
4. **Strengthen teacher professional development in foundational mathematical pedagogy:** Teacher training programmes and professional development initiatives should focus on pedagogical approaches that support foundational mathematical competencies. Teachers should be equipped with strategies that can address conceptual misconceptions and promoting cumulative mathematics understanding.
5. **Encourage curriculum alignment across educational levels:** Curriculum developers and policymakers should strengthen the alignment of the mathematics curricula of basic and senior secondary education to facilitate continuity and progression in learning. Better curricular coherence may facilitate learning progression and reduce knowledge gaps across educational transitions.
6. **Incorporate foundational mathematical competencies in educational intervention policies:** Educational interventions to improve mathematics performance should explicitly recognize foundational mathematical competencies as a critical component of programme design, rather than focusing exclusively on instructional delivery approaches.
7. **Expand research on foundational mathematical knowledge in Nigeria:** There is a need for future empirical studies to investigate the influence of foundational mathematical knowledge across different educational contexts in Nigeria. Longitudinal and mixed-methods approaches might provide

a more nuanced understanding of how foundational competencies influence later academic outcomes.

8. **Encourage theoretically based mathematics education research:** Researchers need to put forth more comprehensive conceptual and theoretical models that relate foundational mathematical knowledge to cognitive, instructional, and affective factors that affect mathematics performance.

Foundational mathematical knowledge should be considered not only a prerequisite for learning mathematics, but also an important factor in students' long-term mathematics performance. Educational improvement initiatives targeting the strengthening of foundational mathematical competencies may therefore provide a sustainable pathway toward improving mathematics performance and enhancing educational outcomes among Nigerian secondary school students.

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