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Global proficiency framework: Analysis of national and Colleges of Education curricula in Ghana

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Background: Many studies have been done in the past to compare country-specific curricula to international standards. However, there is an apparent lack of literature that focusses on evaluating the alignment of country-specific early grade mathematics curriculum to the Global Proficiency Framework (GPF) for mathematics.

Aim: This study aims to investigate how the domains of the national early grade mathematics curriculum and the Bachelor of Education curriculum for pre-service early grade teachers in the Colleges of Education (CoE) in Ghana align with the GPF for mathematics.

Setting: The study was conducted in Ghana using the national early grade and Colleges of Education (CoE) curricula.

Method: Document analysis was employed to compare the list of domains in the GPF to the lists of domains in the Ghanaian national early grade mathematics curriculum and the Bachelor of Education curriculum.

Results: The results showed an alignment in the list of domains in GPF and the two curricula. The Bachelor of Education curriculum included theories of early-grade numeracy development which was absent in the GPF. The indicators in the two curricula were found to have exceeded the global minimum proficiency levels in the GPF.

Conclusion: The results showed an alignment between the GPF and the two curricula signifies that the mathematics curriculum used for teaching early grade learners in Ghana meets international standards and can help learners compete on a global scale in mathematics learning.

Contribution: The study provided valuable insights for policy-makers to consider while making decisions about curriculum standards and teacher training programmes. This is a significant step towards enhancing the quality of early grade mathematics education in Ghana.

Keywords: mathematics proficiency; mathematics curriculum; early grade; sustainable development goal; global proficiency framework for mathematics; pre-service early grade teachers.

Introduction

Equipping individuals with strong mathematical skills not only empowers them to innovate and contribute to technological advancements but also enables them to address complex real-world problems (Bishop, Seah & Chin 2003). This, in turn, fuels economic growth and societal progress. Therefore, the pivotal role of mathematics education extends far beyond the classroom, acting as a cornerstone for a nation's future prosperity and development on the global stage. Numerous initiatives have been undertaken to emphasise research in the field of early childhood education (ECE) (Graven 2015; Lazic, Knežević & Maričić 2021; Morrison et al. 2023). This collaborative approach seeks not only to advance an understanding of the unique challenges and opportunities in this domain but also to drive positive change in ECE practices and policies. By fostering a culture of research and innovation, these endeavours aim to pave the way for a brighter and more effective educational journey for young learners.

According to research by Eshun (2004) and Eshun-Famiyeh (2005), mathematics is considered the most challenging subject in Ghanaian schools. Ghanaian students' performance in mathematics throughout time reflects this prevalent opinion. Recent surveys (Fletcher 2018; Hagan et al. 2020) indicate that students' performance in mathematics in Ghanaian schools is

low and needs to be improved. Again, the results of the Early Grade Literacy and Mathematics Assessment (EGLMA) also showed that, in Ghana, just 6% of primary school students achieved the necessary standard for numeracy (Ministry of Education [MOE] 2019). This study, therefore, aims to investigate how the domains of the Ghanaian national early grade mathematics curriculum and the Bachelor of Education curriculum for pre-service early grade teachers in Ghana align with the Global Proficiency Framework (GPF) for mathematics.

Aim of the study

This study aims to investigate how the domains of the Ghanaian national early grade mathematics curriculum and the Bachelor of Education curriculum for pre-service early grade teachers in the Colleges of Education in Ghana align with the GPF for mathematics.

Research questions

These research questions were developed to guide the study:

1. *To what extent are the domains of the Ghanaian national early grade mathematics curriculum aligned to the GPF for mathematics?*
2. *In what ways do the domains of the Bachelor of Education curriculum for pre-service early grade teachers in the Colleges of Education in Ghana align with the GPF for mathematics?*

Literature review

Mathematics proficiency

The National Council of Teachers of Mathematics (NCTM) expresses *mathematics proficiency* as 'the ability to use mathematical concepts, procedures, and strategies to solve a wide range of mathematical problems and to explain and justify one's thinking' (NCTM 2002:5 cited in Evans, Leija & Falkner 2001). By this assertion, mathematics proficiency involves procedural fluency (the ability to perform mathematical procedures accurately and efficiently) and conceptual understanding (the ability to understand and explain mathematical concepts and their relationships). While Kilpatrick (2001) defined it as the application of knowledge and expertise in mathematics, the author further argued that mathematics proficiency is not an absolute state but a developmental process that develops over time and is characterised by factors like instruction, practice, motivation, and cultural and contextual factors. Therefore, it is multi-dimensional and covers a range of knowledge, skills, and dispositions. Teachers can employ Kilpatrick's concept of mathematics proficiency to design engaging curricula that emphasise skill development and foster positive attitudes towards mathematics. This approach enables the evaluation of students' mathematical competency, considering factors beyond academic performance, and guides instruction by emphasising the importance of employing diverse teaching strategies, providing ample practice opportunities, and creating an engaging classroom atmosphere to enhance students' mathematical proficiency.

Global proficiency framework for mathematics

Achieving Sustainable Development Goal (SDG) 4 has become the hallmark of most educational systems. There has been a continuous discussion about how to achieve these SDGs; hence, the GPF for mathematics (also referred to as the GPF or the framework) defines the global minimum proficiency levels that learners are expected to demonstrate at the end of each grade level, from Grades 1 to 9. The GPF was developed by mathematics educators, curriculum experts and psychometricians with extensive experience developing and implementing mathematics programmes in a wide range of countries and contexts (Ovsyannikova 2019).

The development process was an extensive one. It began in October 2018 with the development of the Global Content Framework of Reference for Mathematics by the UNESCO International Bureau for Education (UNESCO 2021). The primary objective of the framework is to establish a universal benchmark for worldwide reporting and interpretation of mathematics assessments conducted at national, regional and international levels. It has shown to be an invaluable instrument for countries and organisations aiming to create new assessments that measure progress based on global standards from Grade 1 to Grade 9 (UNESCO 2021). However, the framework gives nations the ability to evaluate how well their standards, curriculum, evaluations, teacher preparation programmes, teaching resources and classroom procedures correspond with the minimal expectations the framework sets for students. Deep discussions on the nature of comprehensive evaluations and the quality of teaching and learning have resulted from using the framework for these new goals (UNESCO 2021).

Countries could benefit from the GPF by having standards, curricula, assessments, and teaching methods all aligned to a single international framework (UNESCO 2021). This could improve the equity and quality of mathematics education. However, it is essential to consider several challenges and limitations. Firstly, despite the importance of procedural fluency and conceptual knowledge, some critics claim the GPF emphasises these strands to the detriment of other mathematical competencies, such as reasoning and problem-solving (Kilpatrick 2001). Secondly, the differences in economic resources, teaching capacity, and cultural norms and communication surrounding education among nations make reaching a consensus on global standards challenging (Kamens & McNeely 2010). Therefore, it will be difficult for certain developing nations to meet the GPF goals without substantial investments in infrastructure and educational change (Walker 2021).

In addition, the emphasis on uniform results may compromise local curriculum autonomy and adaptability to suit changing circumstances. The sociocultural learning environment shapes situational dimensions of mathematical proficiency, as Kilpatrick (2001) points out. Therefore, the GPF's universal measures should be thoroughly verified to guarantee equitable evaluation across all groups.

The Ghanaian basic school curriculum

In the context of Ghana's education system, 'basic education' encompasses the educational journey from Kindergarten one to the first year of Senior High School (MoE 2019). Basic education in Ghana, including curriculum-related aspects, has undergone multiple reforms. To illustrate, in 2017, the Government of Ghana commissioned the National Council for Curriculum and Assessment (NaCCA) to review the basic school curriculum in Ghana, aligning it with global standards (Apau 2021) Subsequently, in September 2019, the Ghanaian government introduced the revised curriculum into the primary education system. The motivation behind this curriculum review was to address deficiencies identified in the previous curriculum, such as excessive content, limitations of the objective-based curriculum, and shortcomings in the assessment system, which failed to provide sufficient data to inform teaching and learning strategies (Aboagye & Yawson 2020).

The new curriculum aimed to enhance the acquisition of essential skills encompassing reading, writing, arithmetic and creativity throughout the primary curriculum while reinforcing the teaching of mathematics (Aboagye & Yawson 2020). This revised curriculum essentially emphasised the value of the '4Rs' Reading, Writing, Arithmetic, and Creativity as fundamental abilities necessary for lifelong learning and the country's advancement. Addai-Mununkum (2020) further pointed out that the new curriculum aims to support the development of 21st-century abilities, including creativity, innovation, communication, teamwork, cultural identity, global citizenship, critical thinking, personal growth, leadership and digital literacy. In the context of Ghana's education system, 'basic education' encompasses the educational journey from Kindergarten 1 to Senior High School 1 (MoE 2019). In the framework of ECE, where the '4Rs' are prioritised, incorporating 21st-century competencies like creativity is essential to preparing learners for life in the contemporary world. Creative children will likely solve complex tasks creatively, think outside the box, and communicate clearly (MoE 2019). Activities that encourage experimentation, imagination and exploration can be incorporated into the curriculum to support creativity in ECE. For instance, children's creative potential can be fostered by combining art, music, storytelling and unstructured play (Cankaya et al. 2023).

Teachers may offer a well-rounded learning experience that develops academic competency and cultivates critical abilities necessary for success in the 21st century by fusing creativity with the fundamental knowledge of Reading, Writing, Arithmetic and Creativity (MoE 2019).

The importance of curriculum materials in teaching

Curriculum materials are important in influencing teachers' instruction. Understanding the curriculum involves recognising how subjects are organised within an academic year and the utilisation of curriculum resources, like textbooks, to structure a student's educational programmes (Shulman 1986). Successful curriculum implementation necessitates the teacher's establishment of a rapport with students and the promotion of individualised learning. This rapport inspires students to innovate and encourages them to confidently explore new learning opportunities (Young 2011). Similarly, Begg (2005) argues that a curriculum essentially constitutes the blueprint for classroom instruction. This implies that the curriculum serves as a framework that facilitates learning by defining the expected knowledge, skills and attitudes to be acquired throughout a course or programme of study. It helps outline the primary teaching, learning and assessment methodologies, along with the necessary learning resources required for effective course delivery (MoE 2019). Because we are living in a global world and a competitive world, it is important national curricula are compared with international standards to find out how they are aligned with international standards. For example, given Singapore's outstanding performance in international assessments, such as the Trends in International Maths and Science Study (TIMSS), the South African education system explored the adoption of the Singapore Mathematics curriculum as a potential alternative (Naroth & Luneta 2015). Singapore's impressive results on global tests have piqued the interest of educational policy-makers in South Africa, who sought effective methods to improve their mathematics education. This was aimed at enhancing their educational standards and providing students with a rigorous and competitive mathematics education, aligning with global benchmarks to foster a more robust foundation in mathematics and science (Naroth & Luneta 2015).

Aligning national curricula with international standards

Some studies have been done in the past to compare some countries's specific curricula to international standards. Reddy et al. (2016) found that 91% of science and 95% of mathematics content are covered in the TIMSS assessment framework when compared to the South African curriculum. This demonstrates how closely the South African curriculum and the TIMSS standards align. Except for earth science content, which is covered in geography rather than natural sciences, most of the content domains evaluated by TIMSS are covered in the South African curriculum (Reddy et al. 2016). Lower performance in the earth science field resulted from this coverage gap (Reddy et al. 2016). The TIMSS exam items cover the cognitive domains of reasoning, applying, and knowing approximately equally. In science, South African pupils underperformed compared to average on knowledge and reasoning items, suggesting that these cognitive areas may need to be adequately covered in the curriculum (Reddy et al. 2016). The areas where the TIMSS framework and the South African curriculum diverge or align offer valuable information about the curriculum's strengths and limitations when compared to international standards. This can help guide choices about curriculum modifications to enhance alignment. Reddy et al. (2016) discovered that South Africa's TIMSS scores notably improved between 2003 and 2015. This finding implies that efforts to align curriculum and instruction to enhance the mathematics and science competencies evaluated by TIMSS have made headway.

The high degree of alignment and improvements over time have facilitated better performance by matching the South African curriculum with TIMSS requirements.

Balagtas, Garcia and Ngo (2019) conducted a study to compare the Philippine 2016 K–12 Mathematics Curriculum with the TIMSS 2015 Grade 4 Mathematics Assessment Framework. The study showed that K–12 Mathematics Grade 4 is more aligned with the TIMSS 2015 assessment framework than mathematics Grade 8, science Grade 4, and science Grade 8 through curricular mapping of experts on the skills in the two documents. While the previous studies focussed on TIMSS and NCTM, it appears that there is lack of literature that focusses on evaluating the alignment of country-specific early-grade mathematics curricula to a global framework for mathematics. It is important to focus studies on the GPF because it is a globally recognised framework that gives nations and international assessment organisations a common scale for reporting progress on indicator 4.1.1 of the SDGs. This framework takes the form of a common definition of the minimum required knowledge and skills that students must demonstrate at critical points in their learning trajectory. Also, it is important to focus research on the mathematics curriculum used for training pre-service early-grade teachers as research findings show that many pre-service teachers do not feel prepared to teach mathematics at the pre-schools (Sujadi, Wulandari & Kurniawati 2019; Taylor 2021). In the face of the rapid and ever-evolving changes characterising the 21st century, the preparation of pre-service teachers has garnered paramount significance in shaping the overall quality of the teaching workforce. Consequently, conducting an analysis that juxtaposes the curriculum content employed in the training of pre-service early childhood educators in Ghana against international benchmarks becomes an imperative undertaking.

Research methods and design

A qualitative design that is content analysis was used to compare the domains of GPF to the lists of the domains of Ghanaian National early grade mathematics curriculum and curriculum for pre-service early grade teachers in Colleges of Education in Ghana. According to Wallen and Fraenkel (2001), content analysis is the examination of the content of a document, which can be either textual or visual. In addition, Best (1959) wrote decades ago that:

> [C]ontent or document analysis should serve a meaningful function in research, contributing vital knowledge to the subject of study, or generating information that is beneficial in assessing and improving social or educational activities. (p. 150)

Again, it's a technique for objectively extracting the characteristics of the information (either textual or visual) from the content of a document.

In this study, we examined the alignment between the GPF and the two curricular documents to identify possible gaps. The GPF was developed by the UNESCO Institute of Statistics (UNESCO 2021) and the two curricula were developed by the Ministry of Education, Ghana (MOE 2019), the official document used to teach in the basic schools and the Colleges of Education respectively in Ghana. The documents were selected with consideration for how well they would support the research goal of analysing curriculum alignment with the GPF. The lists in the domains of GPF were mapped against the lists of the domains of the National early grade mathematics curriculum and B.E.d. curriculum for pre-service early grade teachers in Colleges of Education in Ghana. The analysis was done through the process of document analysis (Wallen & Fraenkel 2001; under NCTM-established process and principles standard for Grades 6–8. kel, 2001; Best 1959), known as curriculum mapping (Great Schools Partnership 2013). In doing the analysis, we diagrammed or indexed the list in the domains of the GPF and the lists in the domains of the two curricula to identify alignments and misalignments to identify gaps. The analysis was done manually by going through the list in the domain of the GPF which includes number and operations, algebra, measurement geometry, statistics and probability and their subdomain (constructs, subconstruct and descriptors), and mapping them against the domain lists in the two curricula and their subdomains (strands, sub-strands, course contents and indicators) to identify their alignments.

Inclusion and exclusion criteria

The focus is on Grades 1–3 since these grades and kindergarten are referred to as early grades in Ghana (MoE 2019). Kindergarten was not included in the study because it was not included in the GPF. The B.E.d. curriculum for pre-service early grade teachers in Colleges of Education (CoE) in Ghana was included in the study because it is the curriculum that is used to train early grade teachers who later become the implementers of the national early grade curriculum. Early grade refers to kindergarten one and two, Grades 1, 2, and 3 in the Ghanaian Education system (MoE 2019).

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

Results

Table 1 shows the domains, construct and subconstruct of the Grades 1–3 GPF for mathematics and the national early grade curriculum for Ghana. The subconstruct and sub-strand respectively represent the knowledge and skills expected to be attained by learners in Grades 1–3 for mathematics proficiency.

To what extent are the domains of the Ghanaian national early grade mathematics curriculum aligned to the global proficiency framework for mathematics?

The GPF has five domains (Table 1) for mathematics at the early grade level. This includes numbers and operations,

TABLE 1: Structure of the global proficiency framework and the national grade mathematics curriculum.

Global proficiency framework for mathematics						National grade mathematics curriculum				
Domain	**Construct**	**Subconstruct**	**Grade 1**	**Grade 2**	**Grade 3**	**Strands**	**Sub-strands**	**Grade 1**	**Grade 2**	**Grade 3**
Number and operations	Whole numbers	Identify and count in whole numbers, and identify their relative magnitude	✓	✓	✓	Number	Whole Numbers: Counting, Representation and Cardinality)	✓	✓	✓
		Represent whole numbers in equivalent ways	✓	✓	✓		Whole Numbers Operations	✓	✓	✓
		Solve operations using whole numbers	✓	✓	✓		Fractions, Representation and Relationship	✓	✓	✓
		Solve real-world problems involving whole numbers	✓	✓	✓					
	Fractions	Identify and represent fractions using objects, pictures, and symbols, and identify the relative magnitude			✓					
Algebra	Relations and functions	Demonstrate an understanding of equivalence		✓	✓	Algebra	Patterns and Relationships	✓	✓	✓
	Patterns	Recognise, describe, extend, and generate patterns	✓	✓	✓					
Measurement	Length, weight, capacity, volume, area, and perimeter	Use non-standard and standard units to measure, compare, and order	✓	✓	✓	Geometry and Measurement	Lines and Shapes	✓	✓	✓
		Tell time	✓	✓	✓		Position and Transformation	✓	✓	✓
		Solve problems involving time		✓	✓		Measurements	✓	✓	
	Currency	Use different currency units to create amounts	✓	✓	✓					
Geometry	Properties of shapes and figures	Recognise and describe shapes and figures	✓	✓	✓					
	Spatial visualization	Compose and decompose shapes and figures	✓	✓	✓					
	Position and direction	Describe the position and direction of objects in space	✓	✓	✓					
Statistics and probability	Data management	Retrieve and interpret data presented in displays	✓	✓	✓					

Source: United Nations, 2020, *The sustainable development goals report 2020*, United Nations, New York, NY, viewed 17 September 2023, from https://unstats.un.org/sdgs/report/2020/; Ministry of Education, 2019, *Basic school curriculum for preschool*, Ghana Education Service

Note: (The tick) means there are Global Proficiency Descriptor (GPD) present for the grade in question

algebra, measurement, geometry statistics and probability. Each domain has a construct and subconstructs (Table 1). The tick (✓) means there are Global Proficiency Descriptor (GPD) present for the grade in question. The presence of GPD means learners are considered to have developed the knowledge and skills for these subconstructs at that grade level (UNESCO 2021). Almost all of the construct under the five domains have GPDs for all grade levels except the construct fractions under number and operations which have GPDs for only Grade 3. This means that according to the GPF, the subconstruct of fractions such as *identifying and representing fractions using objects, pictures, and symbols, and identifying relative magnitude* should be taught in Grade 3 (UNESCO 2021). Again, under the domain algebra, the construct, relations and functions have no GPD for Grade 1. This also suggests that GPF subconstructs like *demonstrating an understanding of equivalence* are not included for Grade 1.

However, the Ghanaian curriculum has four main domains also called strands with sub-strands (Table 1) which correspond with construct and subconstruct in the GPF. Generally, the strands in the Ghanaian national early grade mathematics curriculum align with the domains of the GPF. Although geometry and measurement are merged as a single strand in the early grade national mathematics curriculum, its content aligns with the contents of geometry and measurement in the GPF. Another seeming difference is the use of data for the fourth strand in early grade national mathematics curriculum – it is the use of statistics and probability as a domain name in the GPF. Although exact words were not used for the strand and domain names of the contents aligned with each other, they both focus on how to organise, represent and interpret data from Grades 1–3. This brought consistency in the content of the early grade mathematics national curriculum and the domains of the GPF. This observed consistency makes the early grade mathematics national curriculum a reflection of the GPF.

In what ways do the domains of the Bachelor of Education curriculum for pre-service early grade teachers in the Colleges of Education in Ghana align with the global proficiency framework for mathematics?

Table 2 shows the mathematics contents of B.Ed. curriculum for pre-service early grade teachers in Colleges of Education.

The course contents include number and algebra, geometry and handling data, theories of learning numeracy in the early grade and teaching and assessing numeracy II for early grade. Pre-service teachers are to learn, teach and apply these domains. From the analysis of the B.Ed. early

TABLE 2: Mathematics contents of B.Ed. curriculum for pre-service early grade teachers in Colleges of Education.

Course Content	Topics
Number and algebra	Numbers and numeration systems: Learning, teaching and applying
	Operations and properties on integers. (fractions, decimals, percentages)
	Concept of sets (Sets of numbers, Venn diagrams) and word
	Algebraic expressions, equations and inequalities
	Every day and commercial arithmetic (Ratio, rates, proportion, scales, percentages (taxation, discount, commissions)
	Number bases and modular arithmetic
Geometry and handling data	Plane geometry patterns in shape
	Geometrical constructions
	Vectors and bearing:
	Basic trigonometry:
	Global mathematics
	Mensuration
	Introductory statistics (Patterns in data):
	Basic probability
Theories in the learning of numeracy in the early grade	Why do we teach mathematics in school?
	Teacher beliefs about mathematics and their relation to teaching
	Beliefs underlying the current early grade official curriculum and inclusive classroom practices
	Major theories of learning and teaching of early grade mathematics in inclusive classrooms
	Multiple intelligence and early grade mathematics
	Factors that affect teaching and learning mathematics in the early grade
Teaching and assessing numeracy II for early grade	The mathematics curriculum
	Counting and number relationships
	Place value 10–1000
	Addition: numbers within 19; and then numbers within 99
	Classroom assessment in mathematics in the early grade
	Subtraction: numbers within 19; and then numbers within 99
	Shape, space and measurement

Source: Ministry of Education, 2019, *Basic school curriculum for preschool*, Ghana Education Service

grade curriculum for pre-service teachers that of the GPF showed that the contents of the two are in sync and consistent with each other. Similar domains of mathematical content areas such as numbers, algebra, geometry, measurement and handling data run through the two. Only one difference was observed which was that the content in the B.Ed. early grade curriculum focusses on theories in the learning of numeracy in the early grade; however, theories were not included in the GPF.

Some examples of learning indicators and exemplars in the national early grade mathematics curriculum and B.Ed. curriculum about the global proficiency framework

The GPF has four minimum proficiency levels which are *Below Partially Meets Global Minimum Proficiency, Partially Meets Global Minimum Proficiency, Meets Global Minimum Proficiency and Exceeds Global Minimum Proficiency.*

The result from Table 3 shows the level of the descriptors in the GPF for the domains number and operations and fractions in the national early grade mathematics curriculum and the Colleges of Education curriculum. The majority of the indicators in the national mathematics curriculum exceed the minimum global proficiency level. For example, in the domain of the national early grade mathematics curriculum, the indicator for Grade 1 (numbers and operations) is ***counting given numbers between 0 and 100***. This shows that the indicator in the National early grade curriculum exceeds the minimum proficiency level in the GPF. Again, it is shown in Table 3 that, fraction was not applicable in Grade 1 and Grade 2 in the GPF but it was included in the national early grade curriculum from Grade 1 to Grade 3. The indicators in the B.Ed. curriculum emphasis on pedagogy, demonstrating how pre-service teachers can teach mathematics concepts at the early grade levels.

Discussion

The result of this study shows an alignment of the domains in the GPF and the National curriculum for Grades 1 to 3. For example, the domain name 'number and operations' has the construct 'whole numbers' with the subconstruct such as 'identify and count in whole numbers, and identify the relative magnitude of the whole number'. The domain 'number and operations' aligns with a subconstruct in the GPF for Grades 1–3 are 'Count, read, and write whole numbers' and 'compare and order whole numbers'. From the GPF point of view, when it comes to the domain of number and operation, for instance, early graders are expected to gain the knowledge and skills in writing whole numbers as well as comparing and ordering whole numbers by the end of Grade 3. A similar illustration was seen in the national curriculum for Grades 1–3. For example, in the strand named 'Number', the sub-strand 'whole numbers' learners are expected to acquire knowledge and skills in naming numbers, counting, representing and comparing numbers, as well as utilising place value and the number line, comparing quantities and numbers up to 100. Generally, the knowledge and skills expected to be mastered by early graders in the GPF align with what is contained in the national mathematics curriculum from Grades 1–3 in Ghana.

The findings show that the GPF and B.Ed. Early-grade curricula align with each other. There was only one omission, and that was, in the B.Ed. early grade curriculum's emphasis on theories of early grade numeracy development. Because theories were excluded from the GPF, it was seen to be out of alignment. This is understandable because early graders in Grades 1–3 do not need to learn theories in mathematics at that foundation age. However, pre-service teachers in Colleges of Education need to learn the theoretical basis for learning and teaching mathematical concepts so that they will be better equipped to teach the subject at an early grade. It may be inferred that the B.Ed. early Grade curriculum aims at producing teachers who are well-trained, and competent, and who know the subject in areas like numbers, algebra, geometry and data handling.

Schmidt, Wang and McKnight (2005) argued that coherence is one of the important characteristics that defines standards of high quality. When there are international standards to

TABLE 3: Minimum proficiency level descriptors and indicators.

Domain	GPF Level Descriptors	National Mathematics Curriculum Indicator	Grade Level	Indicators (B.Ed. curriculum)
Number and operations (Whole Numbers) (Solve operations using whole numbers)	Count in whole numbers up to 30.	Count given numbers between 0 and 100 **(Exceeds Global Minimum Proficiency for Grade 1)**	1	Demonstrating place value using base 10 structured materials i.e. 100s, 10s and1s, (bundled/loose sticks; a flat, long, and unit lego-blocks; flat, strip and loose square cut-outs; etc.) using both English and a Ghanaian language; **(Pedagogy based)**
	Count in whole numbers up to 100	Count given numbers between 0 and 1000 **(Exceeds Global Minimum Proficiency for Grade 2)**	2	
	Count in whole numbers up to 1000.	Count given numbers between 0 and 10 000 **(Exceeds Global Minimum Proficiency Grade 3)**	3	
	Add and subtract within **10** (i.e., where the sum or minuend does not surpass 10), and represent these operations with objects, pictures, or symbols (e.g., when presented with a picture of 6 whole bananas and 3 banana peels, match to sentence 9 – 3 = 6 or complete statement 9 – 3 =).	Demonstrate understanding of addition as joining and finding how many altogether and subtraction as separating and finding how many left; numbers 0 to **20** (e.g., Sena has 8 bottle caps. She takes 5 more bottle caps from Kofi. How many bottle caps does Sena now have?) **(Exceeds Global Minimum Proficiency for 1)**	1	
	Add and subtract within **20** (i.e., where the sum or minuend does not surpass 20), and represent these operations with objects, pictures, or symbols (e.g., 16 – 3= __; 12 + 3 =__; when presented with a picture of 12 marbles with 3 more marbles added, complete or match to the number sentence 12 + 3 =)	Use conceptual understanding of addition and subtraction to add, and subtract numbers to **100** e.g., 1. Add a given set of numbers in two different ways (e.g., 35 + 54 and 54 + 35 or 18 + 12 + 3 and 3 + 18 + 12) and explaining why the order in which numbers are added does not change the sum **(Exceeds Global Minimum Proficiency for 2)**	2	
	Demonstrate fluency with addition and subtraction within 20; and add and subtract within **100** (e.g., 32 + 59; solve an addition or subtraction problem presented by images of bundles of tens and ones; use number lines or skips on hundreds grid to reason through or solve addition and subtraction problems)	Use standard strategy or procedure to do addition or subtraction within **1000** e.g., 1. Explain the purpose of a symbol like a square or an underline in a given addition or subtraction mathematics sentence with one unknown (e.g.: 227 + □ = 609) **(Exceeds Global Minimum Proficiency for 3)**	3	
Fractions	Not applicable to Grade 1 in the GPF	Understand the fraction one-half as the quantity obtained by taking 1 part when a whole is partitioned into two equal parts (e.g., Use pictorial representations to explain the fraction half as the quantity obtained by taking 1 part when a whole object is partitioned into two equal parts)	1	Fractions: meaning of fractions, Relationship between common fractions, Decimals and percentages; Using manipulatives, number lines and fraction chat to demonstrate the concept of equal (or equivalent) fractions, operation on fractions (Pedagogy based)
	Not applicable to Grade 2 in the GPF	Understand the fraction one-half and one-quarter as the quantity obtained by taking 1 part when a whole is partitioned into two or four equal parts e.g., 1. Use concrete objects to explain the fraction one-fourth as the quantity obtained by taking 1 part when a whole object is partitioned into four equal parts.	2	
	Identify unit fractions with denominators up to 12 (e.g., 1/5; 1/7; 1/8; 1/10) represented as objects or pictures (as part of a whole or part of a set) in fractional notation (e.g., shade 1/5 of this shape; indicate 1/6 of these objects when arranged in a 3 by 6 array).	1 Understand a unit fraction by explaining the fraction **1 *f*** as the quantity obtained by taking 1 part when a whole is partitioned into f equal parts and that a fraction **1 *f*** is the quantity obtained by taking parts of the **1 *f*** size e.g., 1. Use several pictorial representations (or card cut-outs) to introduce unit fractions like half, thirds, fifths, tenths, etc. and ask learners to identify the fractions A, B, C, D, and E **(Exceeds Global Minimum Proficiency for Grade 3)**	3	

GPF, Global Proficiency Framework.

compare against, it makes it easier to create cohesive norms. The alignment of the national mathematics curriculum with the GPF only shows that the Ghanaian national mathematics curriculum is up to global standards. The results also indicate that the indicators in the national early grade mathematics curriculum generally meet or even exceed the Global Minimum Proficiency Levels (Table 3). This is a positive outcome, as it suggests that the curriculum is designed to ensure that learners achieve a solid foundation in mathematics skills and concepts. The fact that many indicators in the national mathematics curriculum exceed the minimum proficiency levels set by the GPF is a significant finding. It implies that the national curriculum sets higher expectations for learners in terms of mathematics proficiency compared to the global standards. This could lead to better-prepared learners who are more competent in mathematics. Another noteworthy finding is the inclusion of fraction concepts in the national early grade curriculum from Grades 1–3, whereas they were not applicable in Grades 1 and 2 in the GPF. This suggests that the national curriculum places a greater emphasis on teaching fractions at an earlier stage. This could have implications for learners' overall mathematical understanding and preparedness. The results also indicate that the B.Ed. curriculum emphasises pedagogy, specifically on how pre-service teachers can effectively teach mathematics concepts at the early grade levels. This is crucial for ensuring

that teachers are well-prepared to deliver the curriculum and support students in their mathematical learning.

The alignment of the national early grade and the B.Ed. curricula with the GPF has several advantages. Firstly, it ensures that Ghanaian ECE is coherent and consistent. By harmonising the curricula, teachers can concentrate on the fundamental information and abilities critical to learners' growth in mathematics. Secondly this alignment makes it easier for learners to move between academic levels. Learners can move through their education more smoothly and without experiencing sudden shifts in the material or teaching methods when the curricula are interconnected, which affirms the claims of Reddy et al. (2016).

Finally, comparing Ghana's national curriculum to international standards such as the GPF makes it easier to identify areas that need improvement in order to bring the educational system up to standard and aligning national curriculum with international standards aids students to gain a thorough understanding of mathematics concepts (Luneta 2014).

Implications

The result of the study implies that from the list of domains in the curriculum materials if implemented well, Ghanaian learners can participate in mathematics learning, tests and other internationally recognised assessments which align with the domains in the GPF. There is a need to create educational, pedagogical and assessment tools that are accessible to all Ghanaian learners, and capable of developing learners with a competitive international mindset.

While the initial findings are promising, it is important to recognise that curriculum development and education are dynamic processes. Continuous evaluation and refinement of the curriculum and teacher training programmes will be essential to ensure that they remain effective in meeting the evolving needs of learners and society. Policy-makers may need to consider these findings when making decisions about curriculum standards and teacher training programmes. They may also need to allocate resources and support to sustain and further enhance the quality of early grade mathematics education. The result of this study can open opportunities for collaboration with other countries that are also implementing GPFs. Sharing experiences and best practices can lead to cross-border learning and improvements in mathematics education worldwide.

Conclusion

In conclusion, this study has provided valuable insights into the alignment between Ghana's early grade mathematics curriculum and the GPF.The findings demonstrate a commendable alignment between the two, highlighting the coherence and global standard conformity of the Ghanaian national early grade mathematics curriculum. This alignment signifies that Ghanaian learners will be well-prepared to participate in international assessments and compete on a global scale in mathematics learning if all other factors are considered.

Moreover, the study revealed the emphasis placed on pedagogy in the B.Ed. early grade curriculum, showing the importance of preparing teachers to effectively impart mathematical concepts to young learners. This focus on pedagogy can contribute to the development of well-trained and competent educators who can enhance the quality of mathematics education in Ghana.

Furthermore, the inclusion of fraction concepts at an earlier stage in the national curriculum compared to the GPF suggests a proactive approach to mathematics education, potentially leading to a deeper understanding of mathematical concepts among Ghanaian learners. The implications of this study extend beyond the classroom. It underscores the need for accessible educational tools and the development of a competitive international mindset among Ghanaian learners. Overall, this study opens doors for collaboration with other nations implementing GPFs, facilitating cross-border learning, and improvements in mathematics education worldwide. It is a significant step towards enhancing the quality of early grade mathematics education in Ghana and aligning it with international standards.

Suggestions for future research

It is suggested that future research include the analysis of multiple countries with similar educational systems or challenges. Comparing Ghana's curriculum and teacher preparation to those of other countries can provide a broader perspective on strengths and weaknesses. Again, the direct impact of the GPF's implementation on learners' mathematics learning outcomes can be investigated. This could involve assessing learners' problem-solving abilities, critical thinking skills and mathematical reasoning.

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Authors' contributions

M.K.A. conceptualised the study, and contributed to methodology and writing the original draft. A.J. conceptualised the study and contributed to writing, reviewing and editing the article, A.J. also supervised the whole research.

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Data availability

The data that support the findings of this study are available from the corresponding author, D.S.M., upon reasonable request.

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