PRIMARY SCHOOL CHILDREN'S DIFFICULTIES IN NUMBERS AND OPERATIONS PROBLEMS

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ABSTRACT

This research used a mixed-methods descriptive survey approach, where we examined the responses of 47 children in Grade 3 to numbers and operations problems. In this study, we jointly addressed one objective: (1) determining children's challenges in solving addition/subtraction and number-related problems. The problems included 14 items, each comprising 1 to 7 tasks and required participants to answer in one-on-one interview form to identify their problem-solving difficulties. In this study, we qualitatively classified and provided descriptions for the problems encountered accordingly, and we quantitatively analysed the correct and incorrect responses using only descriptive statistics. One of the key findings that stood out was that almost 50% of the children faced difficulties in comprehending and applying number concepts and skills. They exhibited challenges, such as limited knowledge in recalling basic addition/subtraction facts and expressing numbers in multiple ways. While children were observed to have the potential to address problems, they encountered greater obstacles when performing additions and subtractions. Nevertheless, their struggles with numerical problems indicated an underlying incapacity to solve arithmetic operations accurately. The implication is that most children at the start of Grade 3 did not understand number concepts and strategies for solving addition and subtraction problems and required guidance to perform the tasks.

Keywords: Addition And Subtraction, Number Concepts, Grade 3, Mathematics Difficulties

1. INTRODUCTION

Mathematics is crucial in communication and navigating society, significantly impacting individuals' daily lives and professional endeavours Chin & Zakaria (2015) Clements & Sarama (2021) Ministry of Education Ministry of Education. (2019). A firm grasp of mathematics is essential for building a technologically advanced world. Given its importance in human life, proficiency in mathematics has become a vital skill for professionals, researchers, educators, and parents. Many researchers and educators have emphasised that for children to be proficient in mathematics, instruction and learning should be tailored to students' understanding of foundational concepts, such as number sense or numeracy skills Caldwell et al. (2014)Karp et al. (2011). In this regard, learners should be able to comprehend why and how algorithms or calculations are performed Ministry of Education. (2019); Sood & Jitendra (2007).

The components of number sense or numeracy skills form meaningful learning and mathematics comprehension Chin & Zakaria (2015) Clarke et al. (2002); Maclellan, E. (2012). In the mathematics curriculum, number sense instruction is considered the foundational or central part of and a foremost topic Ministry of Education. (2019); National Council of Teachers of Mathematics National Council of Teachers of Mathematics. (2000).

Number sense has been defined in a variety of ways. According to Yang (2003), it is the person's overall comprehension of numbers and their operations, with the capability to build efficiency, accuracy, and flexibility in solving or dealing with number problems. Berch (2005) explained that number sense comprises counting, transformation, knowledge, and estimation. In addition to the four listed, Bryant et al. (2008)mentioned number patterns as an additional element of number sense. Individuals with good knowledge of number sense understand the calculations, the meaning and function of numbers, and the connection or association between numbers and quantities and their usage in daily life. Number sense is a crucial skill that every individual has to master to support one in manipulating numbers in everyday life Ministry of Education. (2019) Mohamed & Johnny (2011).

Concerning its relevance in school mathematics, the topics constituting number sense have been a significant concern and research worldwide. It can be observed from numerous international educational bodies, the Ministry of Education, and practitioners striving to reform teaching and learning mathematics to focus on the component of number sense that forms the fundamental aspect. For instance, emphasis has been placed on Ghana's mathematics education to help students develop the number sense or basic numeracy skills to improve their understanding of mathematics and solve advanced problems in their daily lives Ministry of Education. (2019). The Australian Curriculum claims that learners must be numerate and, thus, comprehend or make meaning with numbers if they are to develop the concepts and skills to utilise mathematics confidently and broadly in their daily lives (Australian Curriculum, Assessment and Reporting Authority, Australian Curriculum Assessment and Reporting Authority. (2015).

Karp et al. (2011) stated that helping students learn the component of number sense and be proficient in mathematical computation is the concern of effective teaching and teachers assuming higher expectations of the children. Learners find meaning and value in the number sense when teachers prioritise its development over mastering and memorising the procedures, rules, and facts tied to written computation. However, studies have found that some students in different countries need more vital numeracy skills when performing number-related problems Mullis et al. (2004) Mullis et al. (2012). Learners can apply varying degrees of success, using the standard pencil-paper algorithms for adding, subtracting, multiplying, and dividing. However, they quickly run into issues when faced with problems requiring them to draw from their conceptual understandings of these concepts (numbers and operations, decomposing and composing numbers, relative number sizes, number patterns and relationships. This means they have grasped the memorisation procedure but need to learn the concept or understand the meaning of numbers.

Concerning this situation, over the past decade, numerous studies have concentrated on number sense. Most of these investigations have centred around two main areas: evaluating students' performance and competence in the number sense or examining the instructional practices of mathematics teachers Eshun (2005) Fuchs et al. (2008); Davis & Wilmot (2010).

Looking at the trend in those two research areas with the concentration on competence in the number sense, the researchers anticipated that learners might be experiencing challenges in some components in performing problems that are number sense related. Hence, due to research limitations that only permit the researchers to tackle some aspects of number sense competency, this research will highlight specific components in this area and examine challenges encountered by learners. Thus, we will focus on numbers (i.e., counting and place value) and operations (i.e., addition and subtraction) that are further broken down into diverse number sense components in the succeeding section.

We focused on those three domains because, according to Karp et al. (2011), effective counting procedures promote number understanding and making meaningful sense of place value provides a framework for breaking down (separating) and combining (grouping or adding) numbers, which significantly aids in solving addition and subtraction. Mix et al. (2014) also argue that knowledge of place value empowers learners to interpret multi-digit numbers effectively, while MacDonald et al. (2018) and Moller et al. (2011) have observed that grasping place value is fundamental to mastering more complex mathematical concepts. Consequently, understanding counting and place value later becomes the basis for comprehending addition and subtraction operations and extending the knowledge to complex areas. Understanding the relationship between subtraction and addition using a part-whole idea Van et al. (2016) has been observed to enable learners to develop comprehensive comprehension and effective computational strategies Baroody (2016); Bussi & Sun (2018). Learners must acquire meaningful concepts and skills and employ appropriate mathematical problem-solving strategies in handling problems.

Given this condition, we aim to contribute to the current research on numbers and operations in number sense. The research also intends to contribute to developing effective strategies and interventions that can improve children's learning and problem-solving abilities in mathematics. Moreover, this study seeks to provide teachers and curriculum developers valuable insights regarding structuring mathematics classroom instructions. The goal is to enhance a deeper understanding of number sense among children, informing effective teaching practices and curriculum development in this area.

1.1. BACKGROUND

While number sense is a relatively recent term in the mathematics curriculum, the focus on practical and efficient learning and grasping mathematics has been extensively examined for over a decade. Previously, it has been incorporated into mathematics education Ministry of Education. (2007) Ministry of Education. (2019). Number sense provides opportunities for the development of learners' ability to estimate, and this concept has been regarded as an essential element of number sense in the past decade. Besides, various education policy documents recommend using mental computation strategies in mathematics instruction. Estimation necessitates mental computation and meaningful learning of computation. Thus, learners require personal computational strategies that they can use to estimate and solve problems and explain and represent their understandings. This approach requires conceptual understanding and not relying on procedural or mechanical procedures Ministry of Education. (2019). The latter hinders learners' development of computational fluency in number problems Ministry of Education. (2007); USAID/Ghana Learning. (2018). The objective of the curriculum requires learners to make sense of calculations rather than just memorising a single rule or procedure.

The study by Eshun-Famiyeh (2005) and the report by Ministry of Education. (2014) emphasised that classroom practices where learners are taught a standard, pencil and paper-based algorithm do not promote conceptual understanding. Hereafter, the education reform specifies the importance of number sense. The primary goal of curriculum documents on the Numbers and Operations Strand is to assist learners in developing numeracy or number sense Ministry of Education. (2019) National Council of Teachers of Mathematics. (2000).

The study by Eshun-Famiyeh (2005) and Okpoti (2004) declared that the advancement of numeracy plays a crucial role in Ghana's basic mathematics education. Though the Ghana elementary curriculum stressed the importance of numeracy Ministry of Education. (2012), research has found that teacher classroom practice neglects the instruction that promotes meaningful understanding (Adu et al., 2010; Mereku (2014); Ministry of Education. (2014).

The 2011 IEA's Trend in International Mathematics and Science Study (TIMSS) report for Years 4 and 8 revealed that Ghanaian children exhibited little knowledge of basic mathematics, such as numbers and operations Mullis et al. (2012). They mentioned that such findings were connected to issues, such as stresses in the intended curricula, the extensively used textbooks, and how the curriculum is implemented (explicit instruction). The report of the Early Grade Mathematics Assessment (EGMA) and National Education Assessment (NEA) has shown that children's numeracy level is shallow Ministry of Education. (2014), Ministry of Education. (2016). Also, it was observed that children have a habit of memorising facts, rules, and procedures more willingly than learning the basic concepts required to make meaning. As a result, these children may struggle to progress beyond a procedural level in their mathematical abilities Ministry of Education. (2014), Ministry of Education. (2016). Mullis et al. (2012); Siniguian (2017). The Ghana Chief Examiner for basic schools emphasised that children's performance in the nation's Basic Education Certificate Examination is low. The report highlighted their weak numeracy skills attributed to their poor understanding of complex concepts Republic of Ghana. (2015). Even among children aged 15 to 18, difficulties persist in solving numbers and operations problems, particularly those involving reasoning abilities, larger numbers, fractions, or decimals West Africa Examinations Council. (2012). The issue is exacerbated by an over-reliance on calculators for problem-solving. These pieces of research revealed that the children's low level of numeracy largely results from the intended curriculum (i.e. syllabus) being silent over the use of mental methods and heuristics, ineffective classroom instructions, teacher knowledge, and socio-economic background. These factors impacting learners' knowledge in a number sense have been affirmed in international research (e.g., Baker, 2019).

As the worldwide stress on numeracy has increased over the past decade, mathematics educators are troubled by the observation that many learners demonstrate limited comprehension of numerical skills when solving problems involving numbers Chin & Zakaria (2015); Mauhibah, & Karso, (2020). Even though in the classroom, learners may display proficiency in executing algorithms, they often show weaknesses in the number sense component, specifically in grasping the meaning of numbers and arithmetic, grasping relative number sizes, decomposing and composing numbers, and identifying number patterns and relationships Mohamed & Johnny (2011) Obed (2019). Research indicates they often exhibit unreliability when performing computations and analysing problems Prathana et al. (2014). This unreliability is typically manifested through mistakes arising from several factors.

Several studies have emphasised children's low performance and difficulties faced in numeracy. For instance, Mauhibah and Karso's (2020) research on mathematics difficulties among primary children revealed that some struggled with subtraction problems involving carrying or borrowing. Similarly, Obed (2019) investigated the errors and misconceptions of Vanuatu children in the four basic operations, highlighting issues in addition and subtraction. Some errors included mistakes in problems with or without regrouping and wrong place values in addition and subtraction.

In another study, Yilmaz (2017) found that children faced difficulties with teen numbers, often misreading numbers like thirteen and fifteen, contrary to the tens number names, which affected their overall problem-solving skills in numbers. Children's misreading or mishandling of numbers leading to poor number sense was also identified by Carmack (2011) and Siniguian (2017), misusing operation signs Senftleben et al. (2012) Zanzali & Ghazali (2018) or incorrectly recording number facts Baroody (2006) De et al. (2009) Siniguian (2017). Jourdain & Sharma (2016) and Mulwa (2014) also identified that children's poor understanding of mathematical terms hindered their ability to make sense of numbers and solve problems effectively.

Furthermore, Mohamed & Johnny (2011) on elementary students in Malaysia noted that, although students exhibit a high level of proficiency in executing algorithms, they generally display weaknesses in their number sense. They revealed various difficulties in number sense, including poor knowledge of counting procedures when solving number problems. The children also exhibited weaknesses in relative number sizes, decomposing and composing numbers, and understanding the meaning of numbers and operations. Research conducted by Dowker & Sigley (2010) and Geary (2004) pointed out that children find it challenging to apply their knowledge of counting or making sense of this concept in solving number problems.

Moreover, Amar's research (2007) on elementary school students' misconceptions of addition and subtraction demonstrated that many students made mistakes in vertically presented problems due to inadequate knowledge of place value. The studies collectively concluded that children's weak grasp of number sense, such as place value concepts, could significantly contribute to their difficulties in solving addition and subtraction tasks.

This condition, with children's poor ability to solve written computations and showing poor knowledge of number problems, was observed by the researcher in the classroom. The children, 8 and 10 years were still struggling to solve number problems. They could perform paper and pencil computations but struggled mentally when asked to do the issues and explain their solution. For instance, they struggle to add two two-digit numbers with/without carrying over or trading in. They relied heavily on paper and pencil and wrote the problem in the vertical representation before solving it accurately. They have yet to learn to employ such concepts reasonably in problem solving. They understand the partially memorised techniques they have been taught. However, they needed to link the known rules to the meaning of the numbers and the arithmetic properties they were solving.

Despite the significance of numeracy, the curriculum still focuses on the element of computation with little emphasis on the component of making sense in solving number-related problems. USAID/Ghana Learning. (2018) mentioned that despite children performing well in traditional computation, they have not acquired the preliminary skills needed to grasp the basic concepts in mathematics and cannot use these skills in circumstances that necessitate them to understand the basic concepts in mathematics.

Mathematics education is vital for young children's growth when they leave school and need to learn and solve problems efficiently to cope with their daily demands Griffiths & Howson (1974) Larson (2018); Ministry of Education. (2019); National Council of Teachers of Mathematics. (2000). For example, basic numerical scenarios like purchasing a discounted phone from a shop necessitate the application of number sense. Without a meaningful understanding of the concept of fractions, children may face challenges in estimating the discounted price of the phone. They might depend on the sales representative to compute their new price in such cases. To help children overcome these challenges when they leave school, teachers must identify their difficulties' specific sources and nature and adapt classroom instruction to enhance their number sense Ojose (2015), Siniguian (2017).

The literature examined suggests that children face challenges and demonstrate limited comprehension in solving problems in the number sense component, particularly concerning the Strand on numbers and operations (addition and subtraction). Most of the research in this area has been conducted internationally, focusing on young children's computation competence and struggles with number sense problems. However, there is a scarcity of research explicitly addressing this issue within the context of Ghana. Therefore, there is a need for a comprehensive investigation of the difficulties encountered by children in solving numbers and operations in number sense problems to foster the development of mathematics education in Ghana.

1.2. RESEARCH QUESTIONS

Expanding upon the previously mentioned studies, we address the following research question: What challenges do primary school children face when solving number-related and number operations problems?

2. METHODOLOGY

2.1. RESEARCH DESIGN, PARTICIPANTS, AND SETTING

The present research employed a mixed-methods survey design Creswell (2009) that involved 47 Grade 3 children (ages 8–13) from one public primary school and one classroom from the urban area in the Effutu Municipality, Central Region, Ghana. They were intentionally selected from the Municipality schools located in Winneba (Municipality capital) and have been part of the nation's assessments on determining early primary school children's improvement in mathematics, which has consistently reported on early graders' abysmal performance and understanding in number sense Ministry of Education. (2014), Ministry of Education. (2016). This sampling technique was utilised so that we could assume they still have poor number sense or face challenges while progressing to higher grades or after being introduced to new concepts. Based on those reasons, it is evident that they could serve as a reliable information source regarding the difficulties encountered by children. Except for three who joined in Grade 2 and three in Grade 3, all were Grade 3 children enrolled in the same grade from Grade 1. There was no repetition or withdrawal at the time (2019-2020 academic year, first term, September) of data collection, and they had all taken the same termly exam set by the district education office for Grade 2 before Grade 3. Their teacher reported that only about 47% of the class scored 70 to 100% on the term exam and always showed interest in learning mathematics. The teacher mentioned five children who required to be repeated in Grade 2 due to poor knowledge in mathematics and other subject areas but were all promoted to Grade 3 based on the education system.

All the children had been taught with the past curriculum Ministry of Education. (2012) during the data collection period, with the primary focus on numbers and operations up to 9999, with little emphasis on understanding numeracy or number sense. The current national teaching syllabus for Ghanaian primary schools requires that by Grade 2, children learn the essential addition, subtraction, and related number concepts up to 1000, which largely involve number sense components Ministry of Education. (2019). However, participants were only taught the new curriculum after the data collection.

A permission letter with a consent form detailing the research project was sent to the district education office, headmaster, and classroom teacher, and assent was provided. A consent letter was also provided to the children's parents, but they were gathered in the school because most could not read. The children's class teacher read and explained to them in the local language (i.e. Fante), and consent was sought. Besides, before the children voluntarily participated in answering the interview test questions, their teacher read and explained the children's consent form, and assent was sought from all children after the discussion. Notably, the class comprised 50 children, a typical class size for most Ghanaian public primary schools, but three were unavailable during the assessment. A typical instruction strategy in the Ghanaian mathematics classroom is not limited to the traditional method, like explicit instruction Ministry of Education. (2014). As stipulated in the curriculum, the medium of instruction in Ghanaian early-grade classrooms is the local language Ministry of Education. (2012). However, research (e.g. Ministry of Education. (2014) **Ministry of Education. (2016)** USAID/Ghana Learning. (2018) has reported that Ghanaian teachers' classroom practice disregards the utilisation of the local language.

2.2. MEASURES

The children were evaluated using a one-on-one interview test called the Mathematics Diagnostic Test Interview (MDTI) instrument. With reliability and validity, the MDTI was adapted and designed based on standardised tests utilised in international research on 1-6 graders (e.g., Clarke et al. (2002) USAID/Ghana Learning. (2018); Van et al. (2016). In Clarke et al.'s research, individual responses from the interview tasks rated over 0.9 in inter-rater reliability and USAID/Ghana Learning interview tests with a reliability score of 0.98. The modified test was validated by the mathematics educators, such as the second author and the children's class teacher. For external validity, due to a small sample size, which is limited to only one classroom and a school, the assessment's findings may not be generalised to the wider population of Ghanaian schools and the broader field of mathematics education. We used both English and Fante Language as the medium of instruction in the test administration to evade the occurrence of language constraints as a determinant that could influence the credibility of the results of this research.

The MDTI consists of 14 items, except for the oral counting item; each other task has at least four sub-tasks, making it all 69 items (49 on the number concepts and 20 on addition and subtraction operations). It was categorised into three domains of the number sense framework, named EGMA+, designed by USAID/Ghana Learning. (2018).

1) **Procedural knowledge:** This implies the ability to carry out procedures efficiently, appropriately, accurately, and flexibly and consists of the following:
    - Counting numbers orally and sequentially: This implies the ability and automaticity in counting from 1 to 100;
    - Identification of written numbers: This implies the identification of written numbers;
    - Knowledge, confidence, and fluency/automaticity with basic addition and subtraction: This implies an understanding of basic number facts involving addition and subtraction and the use of multiple ways to add and subtract numbers;
2) **Conceptual (applied) knowledge:** understanding mathematical procedures, skills, concepts, operations, and relationships and comprises the following:
    - Understanding the meanings of numbers and operations: This implies an understanding of number sense or the base ten number system (whole numbers), involving skip counting (as the ability to skip count forwards and backwards using even intervals (e.g., 2, 5, 10)), and number patterns (to recognise number patterns and predict the following number in a sequence;
    - Understanding of place value and numeric deconstruction: being able to decompose and compose or represent numbers using 100s, 10s, and 1s flexibly for the convenience of computational fluency;
    - Recognising relative number size: This infers the ability to judge differences by comparing numbers.
    - Understanding mental mathematics: This implies one can mentally solve arithmetic problems without utilising traditional or written computation, as the ability to identify numeric combinations quickly and accurately and complete mental arithmetic using diverse strategies;
3) **Mathematical reasoning and communication:** Describe numbers and apply knowledge of the operation and numeric representations. Also, one can apply existing skills and knowledge to solve unfamiliar problems, including;
    - The ability to think lithely about numbers and their relationship by describing numbers in diverse ways (e.g., using diverse arithmetic combinations and placement on a number line to describe quantities).

In summary, the items in the test include problems on number sense; the first Strand: numbers (i.e., counting sequences, skip counting, subitising, part-part-whole, comparing numerical magnitudes, recognising, describing, pattern, and place value concepts) and the second Strand: operations (i.e., addition and subtraction of two one-digit and two two-digit sums and differences), details of the MDTI is in Appendix 1. We conducted the participant interviews individually and in their classroom, taking about 20-30 minutes per child. Their responses were audio-recorded, and the children's written works were compiled.

2.3. DATA ANALYSIS

To maintain the study's scope and address the research question, we analysed the children's responses on all 14 tasks and data analysis was primarily limited to descriptive statistics and thematic analysis. After reviewing the literature, we adopted the following criteria that ensured tasks include verbal representation and are administered orally. The items were visible to children using the stimulus sheets and were placed in front of them to identify and respond to the tasks. While the researcher held the interview tool, each item was read individually. Participants were asked to produce their answers concerning their correspondence to options on the stimulus sheet USAID/Ghana Learning. (2018). They were also given answer sheets or paper and pencils to write their answers to the addition/subtraction tasks but were encouraged to produce answers verbally and mentally. In fact, the addition/subtraction tasks are test items that could be solved using diverse computation strategies, and participants were asked to justify or explain their answers.

Besides, they were allowed to use manipulatives (sticks, paper, and pencils) to solve addition and subtraction problems but were motivated to avoid using them. An item or a question that was responded accurately was given a point/score of 1 and answered wrongly or with no attempt with 0 points USAID/Ghana Learning. (2018) Yang (2003) Yang (2008). Marks were not given to incomplete responses. Hence, the summation score earned for the MDTI was 69 points. We used SPSS v. 20.0 to tabulate the mean correct and incorrect responses of participants to provide information on the difficulties demonstrated by the children.

Regarding the qualitative data, children's verbal and written responses from the MDTI were assessed using the EGMA+ framework USAID/Ghana Learning. (2018) to categorise and describe the identified difficulties accordingly. The identified challenges were further put into themes using a thematic analysis approach Creswell (2014). This approach was done by coding the raw identified categories and then combining the corresponding challenges revealed by the children. The final themes were further described using quotes (transcribed verbatim) and illustrations to assist in interpretation. We triangulated the verbal and written data sources to provide a comprehensive description to understand their challenges better. The qualitative analysis was also supported by the interview framework proposed by (Yeo, 2009, as cited in Mohamed & Johnny (2011). The framework is as follows:

Figure 1

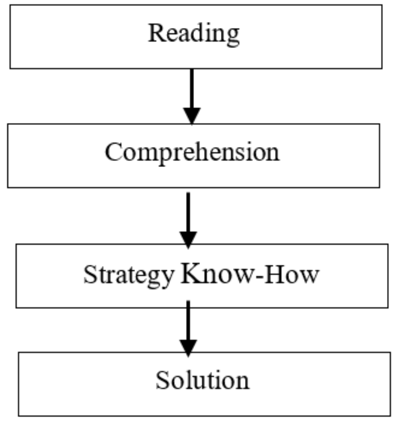

Figure 1 Interview Framework

It is important to note that because the interview questions were read to each participant by the researcher, the steps 'Reading' and 'Comprehension' were not tackled in this study. Using the last two stages, we analyse the data from the addition and subtraction problems. The 'Strategy Know-How' requires the children to tell the interviewer the computation strategy they applied in arriving at the answer, leading to the last phase, the 'Solution' phase. This is how the children were asked during the test interview, 'Could you please explain to me how you solved the problem, or what did you do to arrive at your answer?'. After the participants had answered each problem, they were asked to share their strategies. Transcription from the recorded interview was done to aid in the analysis.

3. FINDINGS

What challenges do children encounter while attempting to solve numbers and operations problems?

Regarding the data collected, the mean number of participants who correctly and incorrectly responded to the one-on-one interview-based assessment using the EGMA+ framework USAID/Ghana Learning. (2018) was tabulated to identify performance and difficulties encountered in the 'numbers and operations' strand to address the research question. Regarding their cognitive demands, the 14 assessment tasks used in the interview were categorised into three domains - procedural knowledge, conceptual knowledge, and reasoning and communication. It is important to note that, after cleaning the data, one respondent's data was discarded. Therefore, only data from 46 (out of 47) participants was used for the analysis. Table 1 presents the results of the children who responded to the 14 tasks correctly and incorrectly.

Table 1

Table 1 Mean (with per cent) correct/wrong children's responses on each of the 14 tasks (N = 46)

Domain	EGMA+ and Number Sense Tasks	Total score	Mean correct (%)[1]	Mean wrong (%)
Procedural Knowledge	Oral counting numbers to 100	1	0.85 (85)	0.15 (15)
	Identification of numbers to 1000	7	3.7 (53)	2.59 (37)

	Subtraction problems level 1	5	2.37 (47)	2.63 (53)
	Addition problems level 1	5	1.91 (38)	3.09 (62)
Conceptual Knowledge	Subitising numbers to 10	5	2.02 (40)	2.98 (60)
	Skip counting numbers to 100	7	3.24 (46)	3.76 (54)
	Partition of numbers to 10	3	1.7 (57)	1.3 (43)
	Missing numbers to 1000	6	2.65 (44)	3.35 (56)
	Deconstruction of numbers to 100	5	2.87 (57)	2.11 (42)
	Place value numbers to 100	5	3.61 (72)	1.39 (28)
	Number discrimination	6	4.72 (79)	1.28 (21)
	Subtraction problems level 2	5	1.24 (25)	3.74 (75)
	Addition problems level 2	5	1.72 (34)	3.28 (66)
Reasoning and Communication	Describing numbers up to 100	4	0.76 (19)	3.24 (81)
	Mean	5	2.4 (49.7)	2.5 (49.5)

[1]Percent in parenthesis

The results show that across the three domains, the children responded correctly to an average of about 50% of the tasks. Even though the best performance was recorded on the procedural knowledge task, oral counting numbers to 100, it was observed that most of the children could only count in English from 1 to at least 50. Surprisingly, none could count from 1 to 50 in Fante (the local Ghanaian language). The maximum number the few who could count reached in Fante was 10. The children who faced difficulty with sequential counting also struggled to perform skip counting (e.g., given intervals in 2s, 5s, 10s) and understand numerical order. They seemed confused with the teens and tens numbers (13 and 30; 19 and 90), negatively affecting their counting procedures.

Figure 2 presents the proportion of children who responded correctly and incorrectly to the 14 number tasks. While over half of the children (57%) failed to provide correct responses for the tasks, the class teacher claimed the children had been exposed to numbers, numerals, and number operations from 0 - 999 before the data collection commenced in this study. This implies that at the study's inception, children had not yet mastered the basic concepts and skills needed to carry out tasks involving numbers and addition/subtraction operations. They have learned these by knowing the answers without experiencing meaningful processes that lead to understanding and applying the concepts.

Figure 2

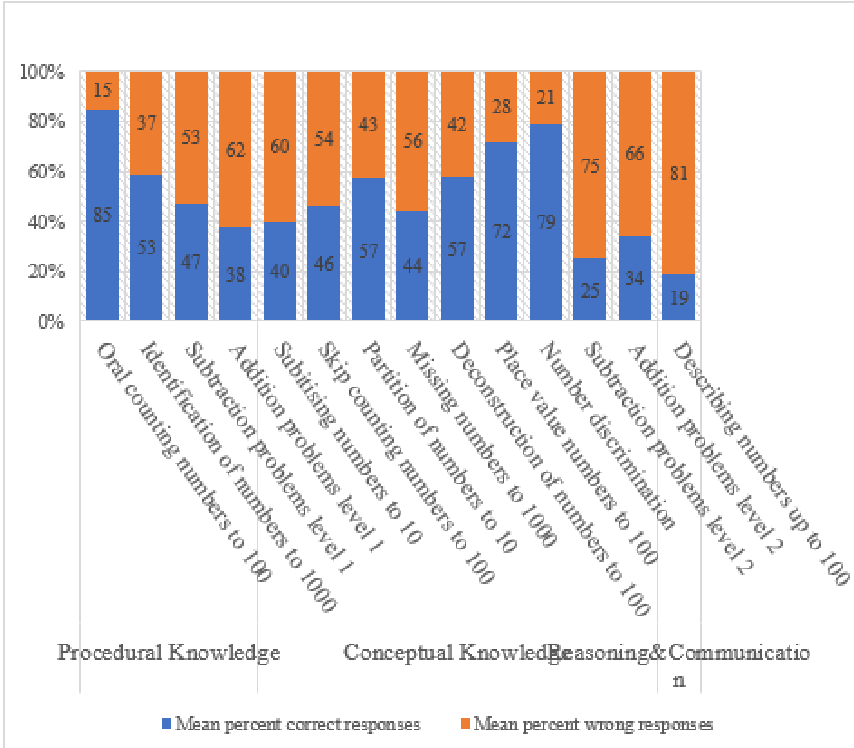

Figure 2 Proportion of Children Who Responded Correctly and Incorrectly to the 14 Tasks

Figure 2 shows two areas where most children (i.e., at least 66%) had the most significant challenges in dealing with numbers and number operation tasks. These are difficulties recalling basic addition/subtraction facts and expressing numbers in multiple ways. These difficulties are discussed next.

3.1. CHALLENGES IN RECALLING BASIC ADDITION/SUBTRACTION FACTS

In the conceptual knowledge domain, the worst performances were on the subtraction level 2 and addition level 2 tasks, in which 75% and 66% of the children, respectively, made incorrect responses Figure 2. Though the children performed better on subtraction level 1 tasks than addition level 1 tasks, with 47% and 38% of them respectively responding correctly to the tasks, they found the subtractions level 2 tasks more difficult than the addition level 2 tasks. The addition/subtraction level 1 tasks used in the assessment to test the children's ability to recall basic addition and subtraction facts are presented in Figure 3. Also, in the figure are tasks used to test the children's ability to apply basic facts and place value concepts to do complex addition/subtraction level 2 tasks.

The children struggle in solving tasks such as "8 + 5 =" and "6 – 3 =". A child answered 12 for "8 + 5 =" instead of 13, and another answered three correctly for "6 – 3 =" but could not use this fact to solve "9 – 6" and responded as 4 instead of three. That is, s/he did not see that subtracting 3 from the subtrahend and minuend results in the expression solved earlier. Nevertheless, the findings revealed that children mostly struggle to recall the number facts for subtraction. They hardly connect those facts to the addition number facts. For example, a child solved "10 + 2 = 12" correctly but could not produce a correct answer for "12 – 2 =". It is important to note that children who could correctly solve addition and subtraction level 1 could not devise a strategy for adding and subtracting in a new context.

Figure 3

Addition level 1 tasks	Addition level 2 tasks
8 + 5 =	13 + 6 =
7 + 8 =	18 + 7 =
9 + 7 =	16 + 25 =
8 + 8 =	24 + 37 =
10 + 2 =	38 + 26 =
Subtraction level 1 tasks	Subtraction level 2 tasks
6 – 3 =	15 - 7 =
9 - 6 =	25 - 7 =
12 – 2 =	33 - 14 =
17 – 4 =	56 – 37 =
19 - 6 =	64 – 26 =

Figure 3 Addition/Subtraction Levels 1 and 2 Tasks

Many children demonstrated proficiency in adding basic addition facts, such as "8 + 8". However, they encountered difficulties applying their factual knowledge to solve more complex problems, like "18 + 7" (see second addition level 2 item in Figure 3, resulting in an incorrect answer of '27'. Consequently, many could not automatically recall that 8 and 7 add up to 15. Additionally, they could confidently perform calculations like "13 + 6 = 19" (see first addition level 2 item in Figure 3) and "38 + 26 = 64" (see fifth addition level 2 item in Figure 3). Nevertheless, faced challenges when asked to employ addition concepts to solve subtraction problems, such as "19 – 6" (see fifth subtraction level 1 item in Figure 3) and "64 – 26" (see subtraction level 2 item 5 in Figure 3. These children perceive subtraction and addition as separate operations without acknowledging the fact that these two operations are interconnected and can be seen as opposite actions. Notably, most children lack comprehension and have difficulty remembering or applying their previous knowledge or learning experiences.

We also analysed children's verbal responses based on their solution process, using the 'Strategy Know-How' (Yeo, 2009, as cited in Mohamed & Johnny (2011), and this was done on the addition and subtraction level 2 subtasks. We only asked a child to explain how s/he solved a problem, provided the answer was correct. It is important to note that most children could not tell how they arrived at a solution. The few who could explain their solution process used mainly 'counting strategies' and 'decomposition strategies' (split numbers into ones and tens). Children who reasonably understood place value concepts mainly used the latter strategy. For example, when a child was asked to show how he got the answer for the problem "13 + 6 = 19", the child verbally said, I counted on from the 13 as 14, 15, 16, 17, 18, 19. Three exceptional children counted on in twos, as 13, 15, 17, and 19, as they kept track of how many twos in 6 to be added. Another child explained the solution process for "15 – 7", as I counted down by 1 from 15 to 7, and another child also explained that I counted upwards from 7 to 15. They kept track of the numbers counted as the final answer, eight. Only two participants could use a 'derived strategy' (i.e., answers were retrieved from known facts) in addition and subtraction level 2 subtasks. Nonetheless, the 'just know the answer strategy' was used by 2 participants on only the addition level 2 subtasks. For example, a child explained that I know multiples of ten and that 20 and 30 are 50 and 4 and 7 are 11, so it is 61

(24 + 37). The child showed an understanding of mental mathematics and of most of the addition and subtraction problems. Though we intended for children to solve the problems mentally, most of them could not devise any mental strategy to solve the problems correctly. Even when they had used the written computation (paper and pencil), they produced wrong responses. Children solving operation tasks with traditional methods/standard algorithms and those executing the problems from the head showed no difference.

3.2. CHALLENGES IN EXPRESSING NUMBERS IN MULTIPLE WAYS

Their worst performance was on the only reasoning and communication task - describing numbers to 100 in multiple ways - in which 81% of the children failed to respond correctly. This abysmal performance is mainly due to an observation in the study where a substantial proportion of the children demonstrated poor knowledge of partitioning and deconstructing numbers.

The results from the data established that 42% of the participants revealed poor place value concepts and could not respond correctly to tasks involving partitioning and deconstructing numbers to 10 and 100. These children could not decompose or compose numbers in ones, tens, and hundreds. When such children were asked to count straws in a bowl in tens bundles and loose ones to make a two- or three-digit number, they could not perform these activities.

Moreover, the children could not use mathematical knowledge to represent numbers in multiple ways. The interview with a child occurred as follows: This started after the researcher provided an example to the child.

Researcher: Can you say the number (40) and describe it in any 4 different ways?

Child 1: It is 14. [child recognised the number as 14 instead of 40 and could not describe it.]

Researcher: Can you say or read these numbers (25, 36) and describe each?

Child 1: [remained silent and] said 25, described as 2 and 5 and 36 as 3 and 6.

From the excerpt, this child, among others, has not fully grasped the knowledge to represent numbers and could not differentiate the teens and tens numbers. Their poor place value knowledge also affected their application with skip counting forwards and backwards. Children's lack of an understanding of place value also affected their problem-solving in addition and subtraction subtasks.

They lack the concept of regrouping- that 10 in any position makes one group in the following place and vice versa. We found that the children demonstrated a misplacement of digits in place value context when solving addition and subtraction level 2 problems. They showed difficulty carrying over or trading on the addition and subtraction problems that require regrouping, even when tasks were written in the vertical representation form. They struggled to switch in borrowing when they needed to trade from the tens to add to the ones to form either ones or tens numbers before performing the subtraction tasks. They consistently solved the subtraction 'with grouping' tasks without considering the value of the digits in the minuend or subtrahend. Perhaps this challenge might stem from children's perception of subtraction solely as a process of 'taking away', which is evident in the formal curriculum. They struggled to grasp subtraction as a means of finding the difference, and they also faced difficulty defining the meaning of individual digits.

4. DISCUSSIONS

This article discusses the challenges encountered by a diverse ability group of students (specifically third graders) when dealing with addition, subtraction, and other number-related problems. It contributes to the existing body of literature on numbers and operations by conducting a thorough analysis of the various mistakes made by the children, thus deepening our understanding of the difficulties they face in solving such problems. Based on the data set, it becomes apparent that the participants encountered specific difficulties. More specifically, 81% of the children failed to describe 'numbers to 100' in multiple ways, and in level 2 subtraction and addition tasks, 75% and 66% of the children, respectively, made incorrect responses. The findings revealed that most children learned more towards procedural understanding than conceptual understanding. The children's grasp of the subject was closely linked to their procedural knowledge. They have limited conceptual understanding and cannot communicate mathematics meaningfully, leading to their poor performance on conceptual and mathematics reasoning items. This result was similar to past studies Ministry of Education. (2014); USAID/Ghana Learning. (2018); they stated that children had learned mathematics as just knowing the answer, as the memorisation of procedures, rules and facts, without making meaningful learning or developing strategy in problem solving. Identifying and analysing errors in problem-solving processes became challenging without a solid conceptual foundation. Consequently, this could result in errors when cultivating an intuitive and conceptual understanding Forrester & Chinnappan (2010) Widjaja et al. (2008).

The findings suggest that the participants lack sufficient knowledge or understanding of the evaluated number-related and addition and subtraction problems, leading to several challenges and low performance. The challenges revealed include an inability to express numbers in multiple ways and a lack of basic number facts. The findings of this study confirmed, supplemented, and strengthened the results of previous authors Amar (2007); Dowker & Sigley (2010); Geary (2004); Mauhibah & Karso (2020) Mohamed & Johnny (2011); USAID/Ghana Learning. (2018), Yilmaz (2017).

4.1. DIFFICULTIES IN EXPRESSING NUMBERS IN MULTIPLE WAYS

This study found that many children experienced difficulties in correctly expressing/representing and reading two- or three-digit numbers due to poor place value concepts. Specifically, they cannot describe, partition, discern, or complete number patterns. They could not establish the relationship between numbers, which affected their problem-solving skills. This result arises from children's inability to visualize decomposing and composing numbers in groups of ten. This may stem from their limited comprehension of the number notation system's theoretical and practical aspects. They lack a fundamental understanding of the base-ten system, which may be due to a lack of experience with numbers. Many studies have found that children's difficulties with number sense stem from wrong or poor place value knowledge Amar (2007); USAID/Ghana Learning. (2018). Children need a firm grasp of place value concepts to perform basic and complex mathematics problems Karp et al. (2011); Moller et al. (2011). Young children in this study may not have had enough exposure to these numbers to understand the patterns and differences fully. They may be more familiar with counting from 1 to 10 and less so with numbers in the teens, tens and hundreds (two- or three-digit numbers), resulting in confusion in reading and expressing numbers in multiple ways. Similar studies Ministry of Education. (2014); USAID/Ghana Learning. (2018) found that children get confused with two-digit numbers (teens and tens numbers) due to less practice and unfamiliarity with the numbers.

The study also revealed that about 20% of the third graders struggled to count numbers from 1 to 100, particularly faced difficulty with counting in the local language. They became disoriented when counting due to poor knowledge of the number names. These children could not understand the number relations, such as cardinality (i.e., knowing how many). This indicates that younger children may need help comprehending the meaning of the numbers; they might merely recite the number sequence. In this study, children's struggles with sequential counting led to errors in skip counting. Their challenges were more apparent in 'counting backwards' because it involves counting in a different direction than they are accustomed to. Perhaps the result is due to memorisation challenges. Learning numbers can involve memorisation, and some children may find it challenging to remember the names and order of teens and tens numbers, especially if they are introduced to them all at once. Consequently, these findings indicated that certain children did not grasp numeral concepts comprehensively. Yilmaz, Z. (2017) states that children's lack of a complete understanding of numerals or confusion with similar-sounding number names led to incorrect responses to number sense tasks, like the backward number word sequences and numerals. The result of this study also parallels past studies that children encounter challenges with counting Dowker & Sigley (2010); Mohamed & Johnny (2011). Students misreading numbers contributed to their weak understanding of numbers Carmack (2011) Siniguian (2017). Evaluating children's comprehension of numbers becomes crucial in shaping instructional approaches to enhance their grasp of numbers and relationships. As Ministry of Education. (2019) asserted, for children to grasp the meaning of numbers in practical everyday situations, they should internalise the meanings associated with those numbers.

4.2. CHALLENGES IN RECALLING BASIC ADDITION/SUBTRACTION FACTS

The finding of this study revealed that most children faced challenges in automaticity and recall of basic number facts, which affected their problem solving. The third graders could not mentally perform number operations problems with sums and differences up to 20. The children were very challenged in solving addition and subtraction problems, which required applying reasoning abilities. They could not utilise their knowledge of addition and subtraction facts to develop mental strategies for solving complex problems. Most relied on a counting strategy (counting on, down, or upwards in 1s and few in 2s). It was found that less than 5% of the children were able to use mental strategies, such as 'derived facts strategy' and 'retrieval (just know the answer) strategy' in solving one and two-digit addition and subtraction problems. This finding parallels De Smedt et al. (2009) and Siniguian (2017), who found that students struggled to recall basic number facts. Moreover, we found that children could not connect addition and subtraction and perceived the two operations to be distinct. Participants' conception of addition and subtraction does not include the case that they are linked as opposite operations.

The overwhelming challenge could be inadequate practice and repetition of basic number facts, leading to poor recording. Suppose children are not regularly exposed to and encouraged to practice these facts. In that case, they may not develop the necessary automaticity in recalling them to solve simple and complex problems

USAID/Ghana Learning. (2018). This finding may also result from educational significance. Children's responses highlight a potential gap in the education system or teaching approaches, indicating that children may not receive adequate instruction or support in developing a strong foundation in mathematics and number sense USAID/Ghana Learning. (2018).. The result may also be context-dependent and related to the developmental stage of the children involved in the study. Younger children might naturally have less developed number sense than older ones; as Yilmaz (2017) highlights, older children with more experience with numbers could work on numerical concept tasks more efficiently than younger children. The difficulties observed in this study might also be due to a lack of meaningful context. Learning in isolation without a meaningful context can make number facts appear arbitrary to children. Creating supportive avenues to enhance children's understanding of mathematics is essential. Thus, young children require compelling and diverse classroom instructions to enhance their mastery of basic number facts, which will support them in applying those facts flexibly, efficiently, and accurately in solving two- and multi-digit addition and subtraction problems.

It is important to note that, in Ghana, little attempt is made by teachers to engage learners in mental math activities that will develop the necessary automaticity in recalling addition and subtraction facts. There is over-reliance on using counters or manipulatives in carrying out basic addition/subtraction tasks by children. Besides, the addition of the 'altogether or counting all' principle is primarily taught in schools. Both the official and implemented curricula experienced by the children in this study are silent over the other conventional strategy for adding (i.e., counting on) and several other heuristics for adding/subtracting numbers, including using doubles, decomposing and then doing 'friendly jumps, subtracting by "compensation"; and so on. The curriculum also does not create opportunities for learners to engage in mental math in class. Addition/subtraction heuristics are often enhanced when children have opportunities to engage in mental math activities, such as 1, 2, or 5 more than (or less than) this number; how many more to make 5? 10? or 20? one (or two) more/less than 10? or 20; mental math cards games with operation cards; and so on.

5. CONCLUSIONS AND SUGGESTIONS

The identified challenges suggest learners will require a mastery of foundational mathematical skills and concepts to reduce mistakes in mathematical problem solving. Moreover, the findings reveal significant gaps in number sense and the need for targeted interventions to improve their mathematical skills. As Dowker & Sigley (2010) and USAID/Ghana Learning. (2018)., intervention studies promote children's mathematical understanding. Teachers must identify and understand children's mathematical difficulties to develop classroom instructions that foster knowledge and effective problem-solving skills. In doing so, employing meaningful context, exposure to numbers, use of various adding/subtracting strategies and heuristics, consistent practice through mental math activities, and establishing a supportive and optimistic learning atmosphere that motivates children to comprehend and grasp fundamental concepts actively is essential.

We acknowledge that the study's constraints revolved around the small number of third-grade participants involved in the research, restricting the variety of responses and making it lack sufficient statistical power to draw robust conclusions, potentially leading to results not representative of the broader population. Additionally, the limited number of number sense tasks restricted the scope and depth of insights, unlike other works Clarke et al. (2002); USAID/Ghana

Learning. (2018)., hindering the ability to generalise findings to various learning contexts/concepts. It is also important to note that some children used tools, such as straws/counters, in solving problems in addition/subtraction problems. However, we did not analyse data from children's usage of manipulatives. Consequently, these limitations could constrain the impact and applicability of the research outcomes. Furthermore, considering that the data is sourced from children motivated to enhance their mathematical learning, there is potential value in extending the study to encompass a more extensive range of settings and diverse academic capabilities. Further research is also required to explore children's use of manipulatives to determine its impact on performance or problem-solving. This expansion could incorporate data from various number sense or mathematical concepts to provide a broader perspective. Perhaps to enhance the teaching syllabus, including the topics necessary for number sense, where learners are exposed to easy and understandable ways to learn and develop strategies and procedures in solving mathematical tasks and become effective problem solvers.

CONFLICT OF INTERESTS

None.

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