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Teaching Identification of Fractions in Context Using the Three-tier Teaching Model's Pedagogy

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Abstract- This paper aims to expand our understanding of culturally relevant pedagogy by utilizing the three-tier model for teaching mathematics in a context. The three-tier model is culturally relevant pedagogy (CRP). It is an innovative teaching approach that draws on learners' sociocultural contexts to scaffold mathematics learning. The study investigated the effects of a culturally relevant pedagogy through the use of the three-tier model on pupils' performance in fractions in Mfantsiman Municipality (MM). The study drew on ethnomathematics and the three-tier model as its main conceptual perspective. We administered a performance test to 426 participants in 12 primary schools in the MM. We analysed the quantitative data using frequency counts, mean, standard deviation, independent samples t-test, and paired samples t-test. We employed content analysis and narrative discussion to scrutinize the qualitative data. The results demonstrated that the culturally relevant pedagogy, specifically the three-tier model for teaching mathematics in a context approach, outperformed the conventional approach, reflecting the regular practices of primary school teachers in MM. The findings have implications for policy and the ongoing professional development of mathematics teachers.

Index Terms- Culturally relevant pedagogy, effects of three-tier model, Mfantsiman Municipality, pupils' performance in fractions, fractions

I. INTRODUCTION

The teaching and learning philosophy of the standard-based primary school mathematics curriculum in Ghana brings to bear the need for effective mathematics education that is needed for sustainable development (NaCCA, 2019). It added that the primary school mathematics curriculum must equip learners with the opportunity to expand, change, enhance and modify how they perceived the world around them. Teachers are to employ a teaching approach that will make learners play active roles in their knowledge creation. Teachers are expected to design pupil-centred lessons that will engage learners physically and cognitively in the knowledge acquisition process in an inquiry-based environment. Similarly, NaCCA also posits in its learning philosophy of the primary school mathematics curriculum that mathematics learning must be perceived as an active process where learners construct their knowledge based on experience rather than acquiring it. To achieve this, there is the need for teaching to be done in a context where teachers will act as actual facilitators through the creation of enabling environment that fosters the creation of learners' knowledge based on their prior experience from the participation in cultural activities in the local settings (Davis, 2010). To make effective use of the learners' sociocultural activities in learning mathematics, teachers must be aware of the learners' mathematical practices in their cultural settings, hence the need for culturally relevant pedagogy. The concept of culturally relevant pedagogy in mathematics education is presented below.

Culturally Relevant Pedagogy in Mathematics Education

Culturally relevant pedagogy (CRP) is an educational approach that recognizes and values the cultural backgrounds of students, integrating these cultural aspects into teaching practices to enhance learning experiences. In the context of mathematics education, CRP aims to make the subject more accessible and relevant to students from diverse cultural backgrounds (Davis, 2016). Cultural relevance in mathematics education involves connecting mathematical concepts to students' everyday experiences and cultural backgrounds (Davis, 2010). Ladson-Billings (1995) and Davis (2010) argue that educators should incorporate students' cultural references into the curriculum to create a meaningful and relatable learning environment. For example, using culturally relevant word problems or real-life scenarios can make mathematical concepts such as fractions, measurement, algebra, etc., more accessible to students. Equity and social justice are central tenets of culturally relevant pedagogy. CRP in mathematics education seeks to address disparities in achievement among students from different cultural backgrounds (Gutierrez, 2017). This includes challenging traditional notions of

mathematical talent and acknowledging diverse ways of approaching and solving mathematical problems. CRP emphasizes student-centered instructional strategies that encourage active engagement and participation. In the mathematics classroom, this could involve collaborative problem-solving activities, group discussions, and projects that reflect students' cultural backgrounds (Davis, 2013; NCTM, 2018). Developing an inclusive curriculum is essential for implementing CRP in mathematics education. This involves selecting instructional materials that reflect the diversity of students' experiences and backgrounds. Additionally, teachers should be flexible in their approach, allowing for multiple perspectives and solutions to mathematical problems (Gutstein, 2006). Research on the impact of culturally relevant pedagogy in mathematics education has demonstrated positive outcomes (NCTM, 2018). A study by Martin, Gholson, and Leonard (2010) found that students who experienced culturally relevant mathematics instruction showed improved engagement, attitudes, and performance in the subject. Similarly, a meta-analysis by Hill, Rowan and Ball (2018) indicated that CRP interventions had a positive effect on closing achievement gaps in mathematics.
Despite the growing evidence supporting the benefits of CRP in mathematics education, challenges remain (Nieto, 2010). Limited teacher training, institutional barriers, and resistance to change are among the obstacles. Culturally relevant pedagogy in mathematics education is a promising approach to creating an inclusive and equitable learning environment. So, acknowledging and integrating students' cultural backgrounds into instructional practices, teachers can enhance students' engagement and success in mathematics. Continued research and collaborative efforts are necessary to overcome challenges and ensure the widespread adoption of CRP, promoting mathematics education that is accessible and meaningful to all students (Davis, 2017). A closely related concept to culturally relevant pedagogy is ethnomathematics. In this study, we conceptualized culturally relevant pedagogy as a teaching approach that relates the school concepts of mathematics to learners' everyday realities.

Ethnomathematics

D'Ambrosio (1985) coined the term ethnomathematics to describe the mathematical practices of identifiable cultural groups. It can be defined as the study of mathematical practices from any culture. Rosa and Orey (2007) define ethnomathematics as members of a group within a cultural setting who are identified with their cultural traditions, codes, symbols, myths, and specific ways of making meaning to each other. Literature has it that the low achievement of pupils in mathematics can be attributed to the absence of cultural harmony in the curriculum in most countries (Rosa & Orey, 2008; Zaslavsky, 1997). So, integrating cultural aspects in the curriculum will promote mathematics learning among pupils. In other words, cultural aspects of mathematics emphasized mathematics from our everyday lives, improving our ability to make meaningful connections and deepening our understanding of mathematics. In this perspective, Davis (2017a) asserted the need for building connecting home mathematics to school mathematics. He emphasized that though home and school mathematics are independent of each other, however, the two are mutually influential in the learning of mathematics.

Ethnomathematics is the mathematical ideas of traditional people (Ascher, 1991). Some ethnomathematics researchers found the tone of Ascher's definition of ethnomathematics to be offensive (Pompeu, 1994; Presmeg, 1998). Pompeu (1994) extended Ascher's definition of ethnomathematics, stating that ethnomathematics is any form of cultural knowledge or social activity that can be recognized by other cultural groups, such as Western anthropologists, but is not necessarily identified as mathematical by the original group. This definition also implies that while some cultures may not recognize their activities as mathematical, others outside of that culture may see them as such. Presmeg (1998) also gave a simpler definition of ethnomathematics. She defines ethnomathematics as the mathematics of cultural practices of a group of people. This definition is more generic and straight to what ethnomathematics is all about. So, drawing on Presmeg's conception of ethnomathematics ideas which was generally about the cultural practices of a group that are mathematical in nature. This re-echoes the cultural, social and historical nature of mathematics which must be situated in the context of practices of an individual or a group of people. Meaning mathematics emanated out of contexts and these contexts are history, social and culture. This implies that in ethnomathematics literature, the perception that mathematics is value-free or culturally neutral is no longer conceivable (D'Ambrosio, 2001; Bishop, 1988; Presmeg, 2007; Davis, 2010). Therefore, teachers' knowledge of pupils' culture influences learning outcomes in mathematics (Ladson-Billings, 1995; Charboneau & John-Steiner, 1988, Davis, 2010). It follows that teachers' knowledge of learners' culture forms the support base for the learning of mathematics in context. Ethnomathematics was developed to bridge the gap between school mathematics and home mathematics.

Ethnomathematics restores the cultural respect for the recognition of one's cultural activities that are mathematical in nature thereby creating the awareness of valuing one's own mathematical culture. Ethnomathematics programmes give local people the leverage to take pride in their own culture. Ethnomathematics reinforces culture, self-respect, and offers a broad view of human beings. Ethnic mathematics is not synonymous to ethnomathematics (Rosa & Orey, 2011). Ethnomathematics in its natural state is devoid of ethnicity. The concept of ethnomathematics is not selective but embraces the cultural nature of all cultural groups and the need to integrate culture into mathematics learning. There is a need for mathematics instruction to take into consideration the cultural background of the learners in the mathematics classroom and use their prior experiences in scaffolding the learning of the school concepts of mathematics (Vygotsky, 1978; Davis, 2017b).

Fractions as Cultural Concepts

Literature has it that fractions are considered a cultural concept because the way they are understood, represented, and used can vary significantly from one culture to another (Bishop, 1993). Some reasons to consider fractions as cultural concepts are presented below. The concept of fractions has evolved over centuries and has been influenced by various cultures. Different civilizations, such as the Egyptians, Babylonians, Greeks, and Indians, contributed to the development of fractional notation and arithmetic. Each culture had its own way of representing and working with fractions. Different cultures have used distinct notation systems for fractions. For example, the use of vulgar fractions (i.e., fractions with a numerator and a denominator) is common in many Western cultures, while other cultures may use different symbols or methods to represent parts of a whole (Saxe, 1994). Fractions are often used in cultural practices and traditions. For example, in cooking, recipes in different cultures may use fractions to specify ingredient quantities, and traditional crafts may rely on fractional measurements for accuracy. The way fractions are described and named can vary across languages and cultures. For instance, some cultures may have specific names for common fractions, while others may use generic terms. The teaching and understanding of fractions can vary significantly across different education systems and regions. Cultural norms and values can influence how fractions are taught and learned in schools.

Cultural perspectives can influence the philosophical approach to mathematics, including fractions. Some cultures may emphasize practical applications of fractions, while others may focus more on abstract mathematical concepts. Cultural contexts can shape problem-solving approaches related to fractions (NCTM, 2018). Different cultures may have unique strategies for solving fraction-related problems or may prioritize certain types of problems over others. Cultural attitudes and beliefs can impact how fractions are perceived. For example, some cultures may place a strong emphasis on precision and exactness in fractions, while others may have a more flexible approach.

Fractions have played a role in historical and religious contexts. For instance, fractions are used in religious rituals, art, and architecture in various cultures, often with symbolic meanings. Fractions can be embedded in cultural expressions, such as music, art, and literature. These expressions may use fractions to convey specific meanings or aesthetics. Literature has it that fractions are a cultural concept because their representation, usage, and significance are influenced by cultural factors (Bishop, 1993). Understanding how different cultures approach fractions can provide insights into the diversity and richness of mathematics and practical knowledge around the world (Bishop,1988; Gay, 2000).

Why should fractions be taught in context?

Teaching fractions in context is important because it helps students understand the practical and real-world applications of fractions, which in turn enhances their comprehension and retention of this fundamental mathematical concept. Some reasons why fractions should be taught in context are presented below.

Teaching fractions in context makes the concept more relevant to students' everyday lives. Fractions are used in various real-life situations, such as cooking, shopping, and measuring, and showing these applications helps students see the value and usefulness of fractions. When students learn fractions in context, they can develop a deeper conceptual understanding of what fractions represent in their everyday context (Davis, 2010). They can see that fractions are not just abstract mathematical symbols but have meaning in real-world situations, like dividing a sugar cane or sharing candy. Contextual teaching of fractions provides opportunities for students to engage in problem-solving. They can apply their knowledge of fractions to solve practical problems, which helps them develop problem-solving skills and critical thinking abilities.

Learning fractions in context can motivate students because they can see how these concepts are used in their daily lives. This motivation can lead to increased interest and engagement in mathematics. Fractions are a foundational concept in mathematics, and understanding them in context can help students build connections to other mathematics topics, such as decimals, percentages, and algebra (Davis, 2010). This interconnectedness can facilitate the learning of more advanced mathematics concepts. In science, technology, engineering, and mathematics (STEM) fields, fractions are used extensively. Teaching fractions in context prepares students for future studies and careers in STEM-related areas. Contextual teaching of fractions can also highlight cultural and social aspects. For example, when discussing recipes from different cultures or sharing resources, students can learn about cultural diversity and fairness. Understanding fractions in context can improve students' ability to communicate mathematically. They can explain their reasoning and solutions more effectively when they have practical examples to refer to (Bishop, 1988). Learning fractions in context can lead to better retention of the material because students are more likely to remember concepts that have practical applications. Mastery of fractions is essential for success in learning more advanced mathematics courses.

The best learning experience is achieved when teaching and learning are done in context (Davis, 2017b). One of the influential aspects of teaching and learning of fraction in context is the classroom discourse that takes learners through the three interrelated levels of Davis' three-tier teaching model for teaching mathematics in context (i.e. enculturation, transition and acculturation) and allows learners to learn mathematical concepts like fractions in multiple ways using their everyday mathematical practices in their cultural settings as a transition experience in scaffolding the concept of the In-School mathematics (Davis, 2010, 2017b). When learners are allowed to learn mathematical concepts like fractions by consciously learning it through the three interrelated levels of Davis' three-tier tier teaching model for teaching mathematics in context, learners learn mathematical concepts by making sense of mathematics through conjecturing, finding patterns, communicating their mathematical ideas with one another, and using multiple representations to make sense of the mathematics they are learning. The context of sharing and comparing In-home/everyday mathematics is not necessarily the same as in In-School mathematics context where the context of fair sharing and comparing are key (Davis, 2010; Davis, Bishop, & Seah, 2009).

The contexts of fair sharing and comparing of any object are also influential because they help pupils/students understand other mathematical concepts in primary school mathematics, such as fractions as division and the importance of the whole when comparing fractions (Fosnot & Dolk, 2002; Dolk & Fosnot, 2006). Because of this, context help learners at the early grade to model whatever mathematical problem they faced visually using diagrams to represent their thinking. The major challenge of learners in learning fractions at the early grade is mainly as a result of the way learners are introduced to fractional concepts at the early grade since this stage form the foundation of most mathematical concepts (Gbormittah, 2022). A context-based model for introducing learners to fractional concepts will help learners to picture the concepts in the context of their day-to-day activities in their cultural settings and use that as a conceptual link in learning the international mathematics (i.e., scientific concept). Studies have shown that culturally relevant pedagogy has positive impact on learners' performance in mathematics (NCTM, 2018; Hill, Rowan & Ball, 2018). No study has looked at the effects of culturally relevant pedagogy on pupils' performance in identification of fractions to the best of the knowledge of the authors, hence the need for this present study to investigate the effects of culturally relevant pedagogy through the use of the three-tier model for teaching mathematics in context on primary pupils' performance in identification of fractions.

Research Questions

The following research questions were formulated to guide the study:

- What is the performance of the pupils in the identification of fractions in the pre-test in the Mfantsiman Municipality?
- What is the performance of pupils in the identification of fractions in the post-test in Mfantsiman Municipality?
- What is the performance of pupils in identification of fractions by context of groups in the post-test in Mfantsiman Municipality?
- What are teachers' views about the use of the CRP for teaching mathematics in context for teaching of identification of fractions in Mfantsiman Municipality?

Research Hypotheses

The following hypotheses were formulated to guide the study:

- **H01:** There is no statistically significant difference between pupils' performance in the control group and those from the experimental group in the pre-test in Mfantsiman Municipality.
- **H02:** There is no statistically significant difference between pupils' performance in the control group and those from the experimental group in the post-test in Mfantsiman Municipality.
- **H03:** There is no statistically significant difference between the control group's pre-test and post-test scores in identification of fractions in Mfantsiman Municipality.
- **H04:** There is no statistically significant difference between the experimental group's pre-test and its post-test in Mfantsiman Municipality.

II. METHODS

Research Design

This study employs sequential explanatory mixed methods including a quasi-experimental pre-test -post-test control group design (Creswell & Creswell, 2018). This research design was found suitable for this study since it intended at investigating the effect of the CRP for teaching mathematics in context on primary pupils' performance in fractions by comparing the conventional instructional method (i.e., those taught using the NaCCA curriculum approach that reflects the usual practices of teachers in the classroom) to that of the CRP approach (i.e., those taught using the three-tier for teaching mathematics in context approach that connects school concepts to learners' everyday experiences). Also, intact classes of the pupils were used to avoid disrupting the school's system of classroom assignment of pupils (Cohen, Manion, & Morrison, 2011). In this study, schools were randomly assigned to either the experimental or control groups, with each participant taking a pre-test and a post-test to assess their performance in the identification of fractions.

Research Participants

The research participants were chosen using a multistage sampling procedure. The first stage involved the selection of

Central Region out of the 16 regions in Ghana using convenient sampling technique to participate in the study. Second, purposive sampling technique was used to select the Mfantsiman Municipality (MM) in the Central Region of Ghana. Third, twelve (12) schools were selected by means of sampling intact classes using simple random sampling technique with six (6) schools in the experimental group (i.e., those that taught using the CRP for teaching mathematics in context approach) and the remaining six (6) schools constituted the control group (i.e., those who were taught using the conventional approach which reflected the usual practices of the teachers in the classroom). The researcher lives in the Central Region of Ghana hence conducting the study in the region would make it easy for the researcher to access the participants and also ensures cost and time effectiveness (Yin, 2009). Lastly, a purposive selection of primary one mathematics teachers and their pupils were done. Primary one mathematics teachers and their pupils were used because primary one is the first level that primary school pupils were to be introduced to fractions in the Ghanaian public primary schools (NaCCA, 2019) and hence were more appropriate to participate in this study. A total of twelve (12) teachers and four hundred and twenty-six (426) pupils participated in the study from MM.

Data Collection Instruments

Pupils' Identification of Fraction Worksheet -pre-test, Pupils' Identification of Fraction Worksheet -post-test were used to collect quantitative data on pupils' performance in fractions. The instruments were developed based on the literature review (TIMSS, 2003, 2007, 2011) and consists of ten questions/items in identification of fractions. The first four questions/sub-questions were of low cognitive order (i.e., pupils were either to name, shade or circle without doing much synthesis of ideas) while the remaining six were of high cognitive order (i.e., pupils were to apply or do synthesis of their concept of halves in the quest to get them right). These items or questions expects pupils to demonstrate their understanding of halves in applying their concepts of halves in the identification of quarters and thirds. Initial pre-testing of the Pupils' Identification of Fraction Worksheet was done using 38 primary one pupils in Komenda-Edina-Eguafo-Abbrem District from Central Region of Ghana. This district was not included in the main study. The instrument was given to other expects in mathematics education to ensure that they met the content and face validity requirements. Semi-structured interview guide for teachers was used to obtained teachers' view on the use of the CRP for teaching mathematics in context with focused groups of four.

Data Collection and Analysis Procedure

The researchers sought ethical approval from the University of Cape Coast's Institutional Review Board. Following the ethical clearance, the researchers also sought permission from the Cape Coast Municipal Director of Education, to conduct the study in the district. The researchers made an initial visit to the district's schools to introduce themselves and obtain consent to participate in the study from the school heads of the selected primary schools. The purpose of the research was explained to the teachers and their pupils, and their consent to participate in the study was obtained. Also, the consent forms were given to the pupils' parents and guardians to allow their wards to participate in the study through their class teachers. The pre-test lasted for 45 minutes for each group (control and experimental). After the pre-test, pupils from the control group were taught twice using the Conventional instruction method lasting for a maximum of 30-60 minutes, while the pupils from the experimental group were also taught twice using the CRP for teaching mathematics in context instructional method. However, teachers in the experimental group went through a day workshop on how to use the three-tier teaching model for teaching mathematics in context before the teaching for both groups started. It was only teachers and pupils in the experimental group that took part in teaching and learning using the three-tier teaching model for teaching mathematics in context instructional package respectively. After the teaching sections for both the control and the experimental groups, the equivalent test was administered as post-test to both groups using 'Pupils' Identification of Fraction Worksheet-post-test. The post-test was made up of the equivalent items in the pre-test. The pre-test and post-test were administered by the first author and six field assistants. The post-test lasted for 45 minutes for pupils in both the control and experimental groups.

The qualitative data was obtained from teachers using the interview guide for primary school teachers from the experimental group on the applicability of the CRP for teaching mathematics in context. The purpose of the Qualitative phase was to probe for details and explanations to the broader picture that emerged in the Quantitative phase of the study. The interview involved a focus group of four members from the experimental group. The interview for teachers lasted for 30-45 minutes. In the main study, the performance test was given to 426 primary one pupils, 210 from the control group and 216 from the experimental group. These pupils were from the district's 84 Basic schools. The author and four field assistants directly administered the performance test. The acquired data was coded and analysed using frequency counts, descriptive and inferential statistics (independent samples t-test and paired samples t-test), while the qualitative data was interpreted using content analysis and discussion. To answer study questions 1, 2, and 3, descriptive statistics (frequency counts, percentages, mean and standard deviations) were used. To answer research question 4, content analysis and narrative discussion were used. Inferential statistics, independent samples t-test was used to address hypotheses 1 and 2, while paired samples t-test was used to address research hypothesis 3 and 4. The inferential analysis was performed using a 0.05 error margin, as used in the results presentation.

Conventional Approach

Pupils are to be introduced to identifying halves in Basic one (NaCCA, 2019), as opposed to (NaCCA, 2012), which requires pupils to be introduced to fractions in Basic two. As a result, the conventional approach (which reflected the usual method of teachers' practices in the classroom) incorporated a set of educational indicators and exemplars intended at assisting pupils in understanding and working with the fraction one-half. These indications and exemplars are intended to assist pupils in grasping the concept of "one-half" and developing the capacity to count in halves by employing both tangible and graphical representations. The indicators and exemplars are presented below.

First Indicator - Understanding One-half: This indicator focuses on helping pupils understand the concept of one-half. It involves two exemplars:

Exemplar One (Concrete Objects): In this exemplar, teachers use concrete objects (e.g., oranges) to explain the concept of one-half. They demonstrate how one-half is the quantity obtained when a whole object (orange) is divided into two equal parts. This helps pupils physically see and interact with the concept of dividing something into equal halves. However, the teacher does not consciously relate the one-half to sharing of objects into halves from their sociocultural context.

Exemplar Two (Pictorial Representations): Teachers use pictorial representations to explain one-half. They show images or diagrams of objects divided into two equal parts, reinforcing the idea of one-half as one of those equal parts. This visual representation helps pupils to connect the concept to visuals but the teacher does not consciously relate the one-half to sharing of objects into halves from their sociocultural context.

Exemplar Three (Sorting Fractions): In this exemplar, teachers use pictorial representations to help learners differentiate between fractions that are halves and those that are not halves. This activity can involve showing various images or diagrams of fractions and having pupils categorize them as halves or not halves. It reinforces their understanding of what a half looks like visually but the teacher does not consciously relate the one-half to sharing of objects into halves from their sociocultural context.

Second Indicator - Counting in halves: This indicator focuses on teaching pupils to count in halves. It also consists of two exemplars:

Concrete Objects: Teachers present several concrete objects, such as half oranges, half pieces of sticks, or half pieces of cards, to the pupils. They guide the pupils in counting these objects in halves using the language "one-half, two-halves, three-halves," and so on. This hands-on approach helps pupils understand counting in halves using real objects but the teacher does not consciously relate the counting in halves to counting halves from their sociocultural context.

Pictorial Representations: In this exemplar, teachers show pupils various images or diagrams representing halves and ask them to count these halves using the same language: "one-half, two-halves, three-halves," and so on. This reinforces the counting concept using visual representations but the teacher does not consciously relate the counting in halves to counting halves from their sociocultural context. This method caters largely for surface learning and encourages rote memorization of the concept.

Three-tier Model as a CRP (Davis, 2017b)

The three-tier model for teaching mathematics in context's approach is presented below. The enculturation phase: Teacher review pupil's previous knowledge on how they obtain halves. Teacher puts pupils into small groups of four or six. Teacher breaks three sticks into two such that only one is exactly half and ask pupils to name/describe the fractions in each case. Here the pupils were to express how they experience halves from their sociocultural contexts. At this stage developer of the model suggests that no scientific concept should be introduced at this level. Then, the teacher asks pupils to consider how tourists from Europe or America might identify halves in their home countries. This is to find out how pupils could identify halves in a way that would enable them to communicate halves to tourists to understand (Davis, 2010).

Figure 1: Representation of fraction of a stick (Davis, 2017b)

Transition phase: Teacher asks pupils to consider how tourists from Europe or America might identify halves in their home countries. Teacher review pupil's previous knowledge on how we obtain halves in their sociocultural settings. Teacher also asks pupils how we obtain halves from other cultures. This is to help pupils to come out with the idea of half as chemu pɛ (i.e., Division into two equal parts) as a prerequisite for the school concept of halves (Davis, 2010). Teacher guides pupils to conclude that halves from the international sense means equal halves (i.e., chemu pɛ). Teacher then explains to pupils

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that Ghana is part of the whole world so while we do what we do in our communities, we have to also learn what is done in the whole world.

Acculturation phase: Teacher brings back the sticks which were used to introduce the lesson earlier and asks pupils in their various groups to look again at the three sticks and identify which one represents half from the international perspective. Teacher puts pupils into small groups of four or six. Teacher gives worksheets containing some artifacts for pupils to shade half of each of them based on chemu pɛ (Davis, 2017b). Teacher brings back the sticks which were used to introduce the lesson earlier and asks pupils in their various groups to look again at the three sticks and identify which one represents half from the international perspective. Teacher puts pupils into small groups of four or six. Teacher gives pupils a worksheet containing group of cultural artifacts and ask pupils to identify half of it using a circle-to-circle half of them. Teacher gives pupils worksheets containing some plane shapes and asks them to shade half of each of them based on the international perspective. Teacher shows a worksheet containing some plane shapes and asks pupils whether the shaded portion for each is half. Teacher asks pupils to represent half of any object symbolically. Teacher then guides pupils to represent fractions using symbols say half of any object as 1/2 where 2 is the number of equal portion of divisions and 1 is the portion taken out of the two equal portions. A mathematics lesson is expected to go through these three (i.e., enculturation, transition and acculturation) stages in an intellectually honest manner.

Prior knowledge: The mathematical concepts, skills, and experiences that pupils have acquired before the introduction of fractions in their learning. This includes foundational skills such as number sense and familiarity with equal sharing or partitioning.

Engagement: The level of active participation, interest, and involvement of pupils in learning activities related to fractions. This construct includes behavioural, emotional, and cognitive engagement, such as attention during lessons, willingness to solve fraction problems, and enthusiasm for collaborative activities.

Understanding: Pupils' ability to comprehend the concepts and principles underlying fractions and apply them in various contexts. This includes recognizing fractions as parts of a any object, interpreting fraction symbols, and solving fraction-related problems with conceptual clarity.

Pupils' Performance in Fractions: The measurable outcomes of pupils' learning in fractions, including their ability to create half by shading half of an object, discriminate between half and non-half-coloured shapes and recognize and write the numeral representation for half and non-half fractions. The diagram below illustrates the hypothesized relationships of the various concepts. The diagram hypothesized that three-tier model positively influences pupils' performance in fractions while engagement and understanding mediate the relationship between the teaching model and performance and prior knowledge moderates the effect of the three-tier model on performance, with students having higher prior knowledge benefiting more from the model.

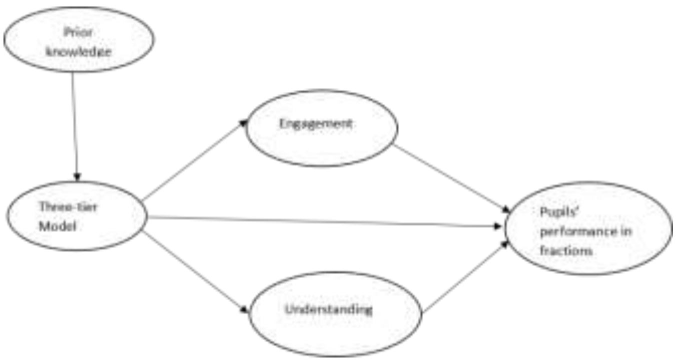


Figure 2: Interconnected factors influencing pupils' performance in fractions

III. RESULTS

Biographical Data of the Participants

Table 1 shows the biographical data of the participants in MM.

Table 1: Biographical Data of the Pupils who Participated in the Study

Contexts		Frequency	%
Gender	Male	220	51.60
	Female	206	48.40
	Total	426	100
Age (years)	6	242	56.8
	7	89	20.9
	8	80	18.8
	9	15	3.5
	Total	426	100
Groups	Control group	210	49.30
	Experimental group	216	50.70
	Total	426	100

Table 1 shows that almost equal number of males 48.2 % and females 51.8% participated in the study from the MM district in the southern belt of Ghana. The average age of the pupils in the MM was 6.2 years. The data was collected immediately when schools resumed after the COVID-19, hence the pupils overstayed in their respective classes in order to make up the lessons. The biographical data in Table 1 also shows that almost equal number of pupils participated in the study from the group (N = 210) and the experimental group (N = 216) in the district. Almost equal number of participants participated in the study from the context of schools in the district.

RQ1: What is the performance of the pupils in the identification of fractions in the pre-test in the MM?

Research question sought to investigate the general performance of pupils in identification of fractions in MM Municipality. Table 2 shows the descriptive statistics of pupils' performance in identification of fractions in the pre-test in Mfantsiman Municipality.

Table 2: Descriptive Statistics of Pupils' Performance in Identification of Fractions (N = 426)-pre-test

Fractional tasks	Percentage of those who had it right N (%)	Percentage of those who had it wrong N (%)	M	SD
1	221(51.9)	205(48.1)	1.04	1.00
2	18()	408(95.8)	0.10	0.70
3a	221(51.9)	205(48.10)	1.04	1.00
3b	213(50.0)	213(50.0)	1.00	1.00
3c	0(0.0)	426(100.0)	0.00	0.00
3d	0(0)	426(100)	0.00	0.00
3e	0(0)	426(100)	1.04	1.00
3f	0(0)	426(100)	0.00	0.00
4a	80(18.8)	346(81.2)	0.40	0.78
4	16(3.8)	410(96.20)	0.08	0.40
Overall	23(5.4)	403(94.6)	3.60	3.54

The results in Table 2 shows that generally majority, 403 out of 426 of the pupils in the MM municipality had low knowledge in identification of fractions in the pre-test. The M = 3.60 out of 22.0 and SD = 3.54 was the overall performance displayed by the pupils in MM municipality.

The standard deviation shows that although the pupils displayed a low performance in identification of fraction however, their performance was closely around the mean of 3.60 in the pre-test.

The results show that none of the pupils were able to handle those tasks (i.e., items; 3c, 3d, 3e, and 3f) that required them to apply their concept of halves among others. Generally, few of them were able to handle some of the tasks that required them the use of low cognitive structures specifically recall.

RQ2: What is the performance of pupils in the identification of fractions in the post-test in Mfantsiman Municipality?

Table 3 shows the descriptive statistics of pupils' performance in identification of fractions in the post-test in Mfantsiman Municipality.

Fractional tasks	Percentage of those who had it right N (%)	Percentage of those who had it wrong N (%)	M	SD
	424 (99.50)	2(0.50)	2.00	0.10
2	394 (92.50)	32(7.50)	3.70	1.10
	425(99.80)	1(0.20)	2.00	1.10
3	425(99.80)	1(0.20)	2.00	1.10
3c	168 (39.40)	258(60.60)	0.80	1.10
3	199 (46.70)	227(53.30)	0.90	1.00
3	296 (69.50)	130 (30.50)	1.40	0.90
3f	27 (6.30)	399 (93.70)	0.10	0.50
4	284 (66.70)	142 (33.3)	1.30	0.90
4	236 (55.40)	190 (44.60)	1.10	1.00
Overall	317(74.40)	109 (25.60)	15.30	4.30

Table 3: Descriptive Statistics of Pupils' Performance in Identification of Fractions (N = 426)-post-test The results in Table 3 shows that generally majority, 317 (74.40%) of the pupils in the MM municipality had high knowledge in identification of fractions in the post-test. The M = 15.30 out of 22.0 and SD = 4.30 was the overall performance displayed by the pupils in MM municipality.

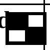
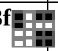
The standard deviation shows that although the pupils displayed a high performance in identification of fraction in the post-test however, their performance was closely around the mean of 15.40.

The results show that majority of the pupils were not able to handle those tasks (i.e., items; 3d, and 3f) that required them to apply their concept of halves among others. Generally, majority of them were able to handle some of the tasks that will require them the use of low cognitive structures specifically recall in the post-test.

RQ3: What is pupils' performance in identification of fractions by context of groups in the post-test in Mfantsiman Municipality?

Table 4 shows control and experimental pupils' performance in identification of fraction in the post-test in MM.

Table 4: Control and experimental groups' Performance in Identification of Fractions post-test

Fractional tasks	Control Group (N = 210)				Experimental Group (N = 216)			
	N (% Pass)	N (% Fail)	M	SD	N (% pass)	N (%Fail)	M	SD
1 	208 (99.0)	2 (1.0)	2.0	2.0	216 (100)	0 (0.0)	2.0	2.0
2 	178 (84.8)	32 (15.20)	4.0	3.40	216 (100)	0	4.0	4.0
3a 	209 (99.5)	1(0.5)	2.0	2.0	216 (100)	(0.0)	2.0	2.0
3b 	209 (99.5)	1(0.5)	2.0	2.0	216 (100)	0	2.0	2.0
3c 	0(0.0)	210 (100)	0.0	0.0	168 (77.80	48 (22.20	2.0	1.60
3d 	32 (15.20)	178 (84.80)	2.0	0.30	167 (77.30)	49 (22.70	2.0	1.50
3e 	80 (38.10)	130 (61.90)	2.0	0.80	216 (100)	0 (0.0)	2.0	2.0
3f 	0(0.00)	210 (100)	0.0	0.0	27 (12.5)	189 (87.5)	2.0	0.30
4a 	68 (32.4	142 (67.60)	2.0	0.60	216 (100)	0	2.0	2.0
4b 	40 (19.0)	170 (81.0)	2.0	0.40	196 (90.70)	20 (9.30)	2.0	1.80
Overall	101 (48.10)	109 (51.90)	11.40	1.9	216 (100)	0	19.10	2.0

The results in the control group (M = 11.40, SD = 1.90) generally show that majority 109(51.90%) of the pupils in the control still have low knowledge in identification of fractions. The pupils in the control group were not able handle the tasks that required them to apply deep cognitive structures. For example, none of the pupils from the control group was able to handle the tasks in item 3f. It is critical to see majority 130 out of 210 pupils in the control group having insecure knowledge in identification of fractions as they still select the picture/diagram in item 3e as halve. This is very worrying and exposes possible weakness in the approach used to teach them. Conversely, their counterparts in the experimental group (M = 19.10, SD = 2.0) generally demonstrated very high knowledge in identification of fractions in the post-test. The pupils were able to apply their knowledge in handling the tasks (i.e., items; 3d, 3e, 4a and 4b) that required them to apply their concepts of halves leaving a few 27 out 216 with insecure knowledge in identification of fractions. STEM education expects pupils to develop more application skills in solving real life problems.

Table 5 shows difference in pupils' performance in the control

		Levene's Test for Equality of Variances		t-test for Equality of Means			95% confidence interval of the difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Lower	Upper
School type	Equal variances assumed	0.189	0.70	1.214	424	0.23	-0.2823	1.19340
	Equal variances not assumed			1.213	423.263	0.23	-0.2830	1.19360

group and those from the experimental group in the pre-test in MM.

H01: There is no statistically significant difference between pupils' performance in the control group and those from the experimental group in the pre-test in Mfantsiman Municipality.

Table 5 shows difference in pupils' performance in the control group and those from the experimental group in the pre-test in MM.

Table 5: Mean Difference between the Control and Experimental Group in the Pre-test in MM

The analysis of results t (1, 424) = 1.214, p = 0.20 in Table 5 shows no statistically significant difference exists between the performance of pupils in the control group (N = 210, M = 4.10, SD = 3.90) and their counterpart from the experimental group (N = 216, M = 3.60, SD = 3.80) in the pre-test. This means that the performance of pupils in the control group and the experimental group were similar in the pre-test in identification of fractions in the pre-test.

H02: There is no statistically significant difference between pupils' performance in the control group and those from the experimental group in the post-test.

Table 6 shows difference in pupils' performance in the control group and those from the experimental group in the post-test in Mfantsiman Municipality.

Table 6: Mean Difference between the Control and Experimental Group in the Post-test in MM

		Levene's Test for Equality of Variances		t-test for Equality of Means			95% confidence interval of the difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Lower	Upper
Groups	Equal variances assumed	0.670	0.414	-41.761	424	0.00	-8.08292	-7.35624
	Equal variances not assumed			-41.789	423.834	0.00	-8.08267	-7.35648

Table 7 shows difference in the control group's pre-test and post-test scores in identification of fractions in MM.

Table 7: A paired samples t-test for the control group in MM

		Paired Differences							
		Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	post-test– pre-test	7.36190	4.29448	0.29635	6.77769	7.94612	24.842	209	0.0

The analysis of results t (1, 432) = -41.761, p = 0.00 in Table 6 shows a statistically significant difference exists between the performance of pupils in the control group (N = 210, M = 11.40, SD = 1.90) and their counterpart from the experimental group (N = 216, M = 19.10, SD = 2.0) in the post-test. This implies that the performance of pupils in the control group and the experimental group differs in identification of fractions in the post-test.

H03: There is no statistically significant difference between the control group's pre-test and post-test scores in identification of fractions in Mfantsiman Municipality.

Table 8: A paired samples t-test for the Experimental group in MM

		Paired Differences							
		Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference		T	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	post-test – pre-test	15.53704	3.99168	0.27160	15.00170	16.07238	57.206	215	0.0

The results in Table 8 indicate a statistically significant difference between pupils' performance in identification of fractions before the use of the three-tier teaching model for teaching mathematics in context approach (M = 4.1, SD = 3.8) and pupils' performance in identification of fractions after the three-tier teaching model for teaching mathematics in context l approach (M = 20.1, SD = 1.8); [t (213) = 56.001, p = 0.0]. Teachers in the experimental group expressed their views about why their pupils had significantly improved in their knowledge in identification of fractions in the municipality. First, one of the teachers appreciated the culturally relevant nature of the model, recognizing that it relates to learners' every day experiences. As one teacher stated, "It relates learners' everyday mathematical experiences to In-school math." (TA). Closely related to culturally relevant nature of the teaching model was how the activities of the three-tier model can support the use of their everyday mathematics: "Sure, I will recommend this model to be used by other teachers because with the "chemu pɛ" (divide into two equal parts) method, it helps learners to relate their In-school concepts of mathematics to that of their home mathematical experiences" (TB). Another strength of the model mentioned by the teachers was that it offers for teachers to learn from the pupils as well. The teachers acknowledged that the approach helps them to make use of the pupils' sociocultural experiences in scaffolding the school concepts of math: "We got new ideas or new things that we don't know from our pupils using the three-tier model's approach." (TC & TD).

Another strength of the model mentioned by the teachers was that it offers flexibility in the use of teaching and learning materials. According to the teachers, this helps in improving children's understanding and reinforces their learning of fractions: "Using the sticks to introduce the lesson to them was different from the other one and the understanding was better than the other one. I think the approach that we used in teaching them is different from the one we were using at first." (TC). Though the teachers acknowledged the effectiveness of the three-tier model, they identified the class control as a key challenge that may serve as a barrier to the use of the model. For instance, one teacher noted the children's inability to regulate themselves and work with instructions, saying that, "When I gave the worksheets out to them, it was quite difficult controlling them. They won't wait for you to tell them what to do, some have even started doing the work on the worksheets. That side was really difficult for me to control." (TD). Therefore, the teachers perceived the three-tier teaching model for teaching mathematics in context as a teaching model that supports CRP. Teachers' views support the need for fractions to be taught in context using the three-tier teaching model for teaching fractions in context pedagogy in Ghana at the Basic School level.

IV. DISCUSSION

Generally, a significant majority of pupils in the MM had low knowledge in the identification of fractions during the pre-test. This was also evident in the similar low performance of pupils from both the control and experimental group in applying their concepts of halves in identifying fractions in the pre-test. Although their performance improved in the post-test specifically in the items that required them to use their low cognitive skills, a significant number of them still had challenge in identification of fractions. For instance, the finding suggests that significant majority of the pupils in the control group, that is approximately 51.90% of the total number of students, still exhibited a low level of knowledge in identifying fractions in the post-test after they have been exposed to the suggested approach by NaCCA (2019) in introducing pupils to identification of fractions in mathematics curriculum for Basic 1-3. In the NaCCA (2019) mathematics curriculum for Basic 1-3, teachers were to first show an object such as orange and tell the pupils that the one orange represent one-whole and cut the orange into exactly two halves. Teacher then picks one of the halves and show to the pupils that the shown part is one-half.

Second, the teacher draws shapes/diagrams/pictures on the board and shade halves of those pictures and tells pupils that the shaded portions show halves. Finally, teachers guide pupils to count in halves (i.e., one half, two halves, three halves, etc.) without any conscious effort in linking the concepts of halves to their everyday experiences. The approved mathematics text books for Basic One also reflected same approached suggested by the NaCCA (2019) Mathematics curriculum for Basic 1-3. For example, mathematics textbook for Basic One, teachers are to show pupils an orange as one-whole, cut the orange into exactly two parts and show one part as one-half (Baah-Yeboah, 2019). Then shade halves of circular and rectangular shapes on the chalkboard to show halves.

Finally, pupils are to just count in halves without any serious conceptual links. This makes the pupils to see the fraction experienced at school and practice at home to be completely disjoint (Davis, 2010; Davis, Bishop, & Seah, 2009; D'Ambrosio, 2001). Hence, the pupils not do see the relevance of the school concepts of halves in their sociocultural context. For example, pupils' attentions are not drawn to the fact that two halves constitute a whole, three halves make one-and halve of whole, four halves are two-whole, etc. Again, fraction as part of a group which could involves going beyond the surface structures was not included in introducing pupils to identification of fractions in some of the mathematics text books like mathematics text books for Basic One (Baah-Yeboah, 2019). For example, none of the pupils in the control group (i.e., those exposed to the approach that reflects the usual practices of the teachers in the classroom) were able to successfully handle the tasks presented in item 3f, which suggests a considerable deficiency in their understanding of identification of fractions (See Table 4). This raises questions about the effectiveness of the teaching approach used for the control group. Similarly, pupils in the control group could not efficiently apply their knowledge of halves in identifying a third and a quarter of objects. The usual practice by the teachers in the control group give pupils very limited opportunity to connect their everyday experiences to the school concepts of mathematics. Learning of mathematical concepts like fractions will be meaningless and irrelevant to the learners if the concept is not connected to their everyday experiences. For example, showing pupils half of an object like an orange without giving them opportunity for them to say the way they experienced halves in their sociocultural setting would make it challenging for them to accommodate the school concepts of halves and apply them in identifying other fractions like a quarter and a third. This could explain possible reasons why the pupils who were exposed to the conventional approach struggled with the identification of halves, quarter and a third, and were unable to effectively apply deep cognitive structures to handle tasks related to identification of fractions.

On the other hand, the performance of the pupils in the experimental group (i.e., those exposed to three-tier approach that connect pupils' concepts of fractions to their everyday experiences) indicates the effects of the CRP for teaching fraction in context on pupils' performance in identification of fractions as noted in literature (NCTM, 2018; Hill, Rowan & Ball, 2018). This was demonstrated in their very high knowledge in identifying fractions after they have been exposed to the three-tier model for teaching mathematics in context pedagogy. With three-tier approach, fraction was considered as cultural concept as noted in literature (Davis, 2010). Pupils appreciate the relevance of the concepts of fractions as they were allowed to talk about how they experienced it in their sociocultural context. The teachers had the opportunity to use multiple cultural artifacts like sticks, loaf bread, cup of water, etc., unlike the conventional approach which was not flexible in the choice of teaching and learning resources (TLMs). For example, a significant number of the pupils in the experimental group were able to apply their concepts of halves in identifying quarters and thirds. Similarly, a significant minority of the pupils in the experimental group were also able to handle the tasks in item 3f which none of their counterparts in control group could do in the post-test (See Table 4). The teachers who used the three-tier model for teaching mathematics in context perceived the three-tier teaching model for teaching mathematics in context as a teaching model that supports CRP. Teachers' views support the need for fractions to be taught in context using the three-tier teaching model for teaching fractions in context pedagogy in Ghana at the Basic School level.

V. CONCLUSIONS AND IMPLICATIONS

In the MM municipality of the Central Region of Ghana, pupils in both the control and experimental groups initially demonstrated similarly low knowledge in identifying fractions during the pre-test. However, a statistically significant difference emerged in the post-test performance between the two groups. Pupils taught using the three-tier approach, which leverages learners' everyday realities to scaffold the teaching and learning of fractions, outperformed those taught using the standard approach recommended by the NaCCA (2019) mathematics curriculum.

Although both groups showed improved knowledge in the identification of fractions in the post-test, the control group, which was taught using the NaCCA (2019) approach, struggled with fraction identification tasks that required deep cognitive processing. In contrast, the experimental group, taught using the three-tier model, successfully solved some of the problems that demanded higher cognitive skills. Teachers using the three-tier model perceived it as supportive of culturally relevant pedagogy.

Given these findings, primary school mathematics teachers in the MM municipality are encouraged to adopt more innovative teaching methods, such as the three-tier teaching model, to enhance pupils' understanding and identification of fractions. This approach not only improves overall performance but also fosters the development of higher-order thinking skills.

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