CULTURAL INFLUENCES ON PRIMARY SCHOOL STUDENTS' MATHEMATICAL CONCEPTIONS IN GHANA

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Declaration

I, Ernest Kofi Davis, hereby declare that this thesis contains no material which has been accepted for the award of any degree or diploma from any University, and to the best of my knowledge and belief, the thesis contains no material previously published or written by another person, except where due reference is made.

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Dedication

This thesis is dedicated to my late mother Rev. (Mrs) Elizabeth Davis

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List of Abbreviations

MOEYS	Ministry of Education Youth and Sports
MOESS	Ministry of Education Science and Sports
OOSM	Out-of-school cultural notions in mathematics
ISM	In-school mathematics
JSS	Junior Secondary School
SSS	Senior Secondary School
GNA	Ghana News Agency
WAEC	West African Examination Council
BECE	Basic Education Certificate Examination
CRIQPEG	Centre for Research into the Quality of Primary Education in Ghana
PTA	Parents/Teachers' Association
SMC	School Management Committee
R	The researcher (Ernest Kofi Davis)
S	All students in a particular school
CR	Culture Related Response
CF	Culture Free Response
HC	Headteacher of school C
TC	Grades 4, 5,and 6 mathematics teachers
SC61	Grade 6 student one from School C
SC62	Grade 6 student two from School C
SC63	Grade 6 student three from School C
SC64	Grade 6 student four from School C
SC41	Grade 4 student one from School C

SC42	Grade 4 student two from school C
SC43	Grade 4 student three from School C
SC44	Grade 4 student four from School C
HL	Headteacher of School L
TL6	Grade 6 teacher in School L
TL4	Grade 4 teacher in School L
SL61	Grade 6 student one from School L
SL62	Grade 6 student two from school L
SL63	Grade 6 student three from School L
SL64	Grade 6 student four from School L
SL41	Grade 4 student one from School L
SL42	Grade 4 student two from School L
SL43	Grade 4 student three from School L
SL44	Grade 4 student four from School L
HX	Headteacher of School X
TX	Grades 4, 5,and 6 mathematics teachers in School X
SX61	Grade 6 student one from School X
SX62	Grade 6 student two from School X
SX63	Grade 6 student three from School X
SX64	Grade 6 student four from School X
SX41	Grade 4 student one from School X
SX42	Grade 4 student two from School X
SX43	Grade 4 student three from School X
SX44	Grade 4 student four from School X
HW	Headteacher of School W

TW6	Grade 6 teacher in School W
TW4	Grade 4 teacher in School W
SW61	Grade 6 student one from School W
SW62	Grade 6 student two from School W
SW63	Grade 6 student three from School W
SW64	Grade 6 student four from School W
SW41	Grade 4 student one from School W
SW42	Grade 4 student two from School W
SW43	Grade 4 student three from School W
SW44	Grade 4 student four from School W

Abstract

Students' performances in mathematics in Ghana have not been as good as they should be (Ministry of Education Science and Sports, 2007; Ministry of Education Youth and Sports, 2004a). Concepts such as fractions and measurement have often been cited as being problematic to students but these are the very concepts which students have much prior knowledge of, through their engagement in out-of-school/everyday mathematical practices in Ghanaian society. In other contexts researchers have highlighted the role that culture plays in mathematics teaching and learning (Bishop, 1991; Seah, 2004). This study therefore sought to investigate cultural influences on primary school students' mathematical conceptions and practices in Ghana, as they move between contexts of out-of-school mathematical practices (OOSM) in the home and in-school mathematical practices (ISM) in the school. Three theoretical lenses were drawn to illuminate the problem. These included the cultural nature of mathematical knowledge by Bishop (1988), sociocultural theories on learning by Vygotsky (1978) and students' transitions between contexts of mathematical practices by Abreu, Bishop and Presmeg (2002). Two main research issues and seven research questions were posed to guide the study. The main research issues were:

1) What are the sociocultural influences on Ghanaian students' mathematics learning?

2) What are Ghanaian students' transition experiences between the home and school contexts and how do these affect their learning in school?

Questionnaires were administered and responded to by 137 primary school teachers and 24 of their headteachers, from 25 (out of all 74) primary schools, selected through stratified random sampling in the Cape Coast Metropolitan area in Ghana. The selection was followed by interviews with 32 primary school students (four each from grade 4 and grade 6), their teachers and headteachers from four (out the 25) schools. Documentary evidence of how teachers handled culture differences was also collected. The data gathered from the closed ended items in the questionnaire survey were analysed quantitatively through the use of frequency counts and descriptive statistics (means) whilst the open ended items were analysed qualitatively, as were the focus group interviews as well as interviews with teachers and headteachers.

The study revealed that exposure to school mathematical culture influences the use of OOSM in ISM in some cases; students' perceptions about mathematics reflected those of the headteachers and teachers; students identified with school mathematical culture (ISM) despite their recognition of OOSM also as a form of mathematics; evidence of cultural influences was observed especially in students' conceptions and practices in identification of arithmetic fractions and division (as in sharing) in real life problems; students mistakes appeared to largely depend on out-of-school logic; generally practical activities evoked out-of-school thinking whilst paper and pencil activities evoked in-school thinking; teachers generally ignored cultural differences and rather concentrated on teaching school mathematics.

The study recommends the need for teachers to see beyond students' mistakes, as their mistakes could be based on a different logic system. In order to make mathematics more realistic to students, a three-tier teaching strategy is proposed to gradually expand students' mathematics schema to include ISM.

Chapter One - Introduction

> “We use Kilogrammes in school mathematics and margarine cups at home” (SC42, a grade four student participant in School C; 2/12/2008)
>
> “They [the students] know the home one [everyday/out-of-school mathematics] so if they bring it up you teach them what the syllabus says or what has been prepared to be followed” (TC, the teacher of SC42, 20/10/2008).

These quotes from a student and her teacher show the place of the local aspect of culture in mathematics pedagogy in the Ghanaian context. However, according to Scholnick (1988):

> it is taken for granted that mathematics learning is embedded in a cultural context. Yet there are many cultural contexts within a society so everyone does not approach adding and subtracting in the same way … it is equally important to specify the necessary bridging structures between home and school and between one concept and another that enable the child to learn mathematics. (p. 87)

Other researchers have also identified the local aspect of culture as playing a significant role in the teaching and learning of mathematics (Bishop, 1991; Presmeg 1998; Seah, 2004). Some of the countries that are perceived as doing well in mathematics and science in the world today recognise the importance of cultural aspect of mathematics teaching and learning. The Netherlands for instance has made use of one aspect of their culture, namely the concept of realistic mathematics education, to improve their mathematics teaching and learning. This idea emphasises the need to choose mathematical problem that are meaningful or real to the child. Other formal school systems, however, usually deepen the gulf between mathematics within cultures (out-of-school mathematics) and school mathematics, rather than bridging the two. In this chapter the researcher throws some light on the Ghanaian situation by looking at firstly Ghana in context, followed by Ghanaian students’ mathematics performance, the researcher's personal context, possible source(s) of students' poor mathematics achievement, and then the statement of problem. The purpose and importance of the study, definition of key terms used in the study and organisation of the study will also be presented in this chapter.

1.1 Ghana in Context

1.1.1 Overview of Ghana: Location and Demographics

Figure 1.1. Location of Ghana.

Ghana is located in West Africa. It is bounded on the north by Burkina Faso, on the west by Ivory Coast, on the east by Togo and on the south by Gulf of Guinea. Ghana was a former British colony under the name of Gold Coast. Ghana was the first sub-Saharan African country to obtain her independence on 6th March 1957. The country became a republic in July 1, 1960. The country covers an area of 238534 km^2 with a population of 23478000 (2007 estimate; United Nations, 2007 report) and a population density of 98/km^2. The adult literacy rate is 58% (66% of the males are literate whilst only 50% of females are literate; UNESCO, 2009). The country is divided into ten regions and 138 districts with its capital called Accra. The most predominant religion in Ghana is Christianity (63% of the population are Christians). The major tribes are Akans (49%), Moshi-Dagomba (16%), Ewe (13%), Ga (8%) and others (0.2%).

Like most British colonies, English language was the main legacy the British left with the Ghanaians. Other legacies left by the British include a democratic parliamentary system of government, the boarding school system, the imperial system of measurement and a respect for white-collar jobs (due to respect for academic rather technical/vocational education). English is the only official language of Ghana, although some 49 languages and dialects are spoken in the country. Nine of these languages (other than English) are government-sponsored and are therefore studied in schools, these being Akan, Dagaare/Wale, Dagbane, Dangme, Ewe, Ga, Gonja, Kasem and Nzema. Hausa is the lingua franca spoken among the country's minority, especially in the north, whilst Twi is spoken by the Akans in the south.

Ghana's GNP/GNI per capita is US$635 (2007 estimate; United Nations, 2007 report), with agriculture being the backbone of her economy. The agriculture sector employs about 60% of Ghana's labour force. The major export commodities of the country include cocoa, gold and timber.

Whilst this study will not take into account all these demographic variables, the choice of region and the research locale in this thesis for example were governed by knowledge of the different languages, as will be seen in Chapters Three and Four.

1.1.2 The Formal Education System in Ghana

Ghana presently has a system of a 12-year pre-university/pre-tertiary education. This is made up of six years of primary school education, three years of junior secondary school education and three years of senior secondary school/technical/vocational education. Primary school education for children typically begins at the age of six. The medium of instruction at the lower primary (Grade 1-3) levels is still the local language (spoken in the local community where the school is situated) with English being used as the medium of instruction at all other levels. It is worth noting that even though local languages are supposed to be used as the medium of instruction at the lower primary levels, all books (textbooks, work books and teachers' handbooks) at this level, with the exception of Ghanaian language books, are written in English. This presents challenges for students, who have to grapple with the onerous task of receiving instruction in one language but read their textbooks and do assignments in another language. The progression from primary school to junior secondary school (JSS) does not require external examinations. The majority of primary school children therefore gain access to junior secondary school. The progressions from junior secondary school to senior secondary school (SSS) and from SSS to tertiary level, however, require national examinations.

Whilst Ghana has made some strides in the expansion of access to basic education, the problem of the quality of education still persists (Akyeampong & Lewin, 2002; EQUALL Project, n.d.), especially the quality of mathematics and science education. The average gross enrolment ratio (GER) from 2002-2005 for instance was about 83% and 69% for primary and junior secondary school levels respectively. The average pass rate of students at the Basic Education Certificate Examinations (BECE) in mathematics and science from 2002-2004 was 64% and 63% for mathematics and science respectively. The Ghana education service has therefore cited expansion in access to basic education as one of the service's achievements in recent years. This organisation however, cites improvement in learning achievement of pupils as one of the major challenges they have faced in recent years (Ministry of Education Science and Sports, 2007).

It is reported that only 30% of students who complete JSS (grade 9) gain access to SSS (grades 10-12) and between 15 to 20% of them gain access to technical/vocational institutions. The remaining 50% or more find themselves either in the informal sector as craftsmen apprentices or self-employed. Out of the 30% who make the transition from JSS to SSS, only 10% go on to the tertiary level (MOESS, 2007). The situation has been succinctly described by MOESS in this quotation "this critical mass of inadequately prepared JSS and SSS graduates at the pre-tertiary level constitute a large body of human resource that must be trained in order for them to contribute to national growth and development" (MOESS, 2007, p.1). Three committees were therefore set up between 1966 and 2002 to address issues of quality and relevance of the Ghanaian educational system in the light of the large numbers of unemployed youth who are deficient in basic numeracy and literacy skills. According to the report of the 2002 Educational Review Committee:

> Basic education as currently structured and delivered in Ghana, comprising primary and JSS [junior secondary school] training, is inadequate to equip our young pupils with the basic reading, writing and numeracy skills required for further mass training at the secondary level to international standards. Neither does it equip them, as promised in the 1987 reforms, with practical skills for the world of work. (MOEYS, 2004b, p11)

Most Ghanaians share the same view as the committee findings, with regard to the persisting phenomenon of a large number of unemployed youths. The question is; why should this be the case? What might have accounted for this trend in affairs in Ghana?

The perceived failure of the educational system has therefore necessitated the implementation of new educational reforms since September 2007. Under the new educational reform, the period of pre-university education is increased from twelve years (6, 3, 3) to thirteen years (6, 3, 4) with the assumption that the increase in duration will offer opportunities for students to receive further pre-tertiary training or skills training. However, it is one thing to introduce more time in the school system for the learning of subjects including mathematics, and another thing for teachers to use the extra contact hours effectively with appropriate teaching methods and capitalising on the children's environment and culture to bring about the desired students' learning outcomes (see Draisma; 2006; Laridon, Mosimege & Mogari, 2005; Cherinda, 2002).

It is evident from the above that even though desire for quality education for the masses is very great the attainment (as will be demonstrated below) seems to elude the nation at the moment. Ginsburg (1988) has said that:

> to understand the failure of the educational system, we need to explore a host of problems usually cited in cognitive research – problem of bilingualism, culture, class, gender, affect, learning style, motivation, availability of sound educational opportunities, teacher competence, the implemented curriculum (as contrasted to the intended curriculum), and the like. (p xi)

The implication here, therefore, is that culture and bilingualism could be two of the independent variables that could easily influence learning outcomes, especially in mathematics among students in schools. However, as will be demonstrated in the next Chapter, there is a paucity of relevant research studies into issues of culture (including language) and students' learning outcomes, while at the same time students' poor learning outcomes, especially in mathematics, has been a matter of concern attracting media attention for some time now in Ghana (see GNA, May 2005).

1.2 Students' Performance in Mathematics in Ghana

Ghanaian students' performance in mathematics both locally and internationally has not been as good as it should. Concepts of number (fractions), measurement, shape/geometry, algebra and word problem solving have been identified as being problematic to basic school children in Ghana (Davis & Hisashi 2007; WAEC, 2006; Duedu, Atapka, Dziyella, Sopke & Davis, 2005; Ministry of Education Youth and Sports, 2004a). A research study carried out by the Centre for Research into the Quality of Primary Education in Ghana (CRIQPEG) on behalf of the Catholic Relief Services (USAID) in mathematics and English at the primary school level (Primary 2, Primary 4 & Primary 6) in the three Northern regions of Ghana revealed that a majority of students' performance in mathematics was far below average (i.e. 50% of the total score of the test). This research found that students experienced difficulty with all the content areas tested with the worst areas being number, measurement, and shape. At the Primary 2 level for instance, the study revealed that students did not have the concept of zero as many of the students wrote four as the answer to the questions "three plus zero" and "five minus zero". Primary four students had problems with the identification of fractions while those from primary six struggled with the identification of odd and even numbers (Duedu, Atapka, Dziyella, Sopke & Davis, 2005). A study conducted in the south by Davis & Hisashi (2007) at the primary school level revealed a similar pattern.

The situation in the international comparative studies is no better. Ghana was last but one (45th out of 46 participating countries) in the 2003 Trends in International Mathematics and Science Studies (TIMSS) examination at grade eight level. The mean percentage correct answer on all the mathematics test items for each participating Ghanaian students was 15%. The overall mean mathematics achievement score for Ghanaian students was 276, far below the international average of 467. Ghana ranked 46th on the international benchmark for mathematics. To understand the situation further, it might be useful to examine the performance of Ghanaian students according to the international benchmarks. Students reaching a specific benchmark exhibit not only the knowledge and understanding that characterise that benchmark, but they also exhibit the knowledge and understandings of students at a lower benchmark. Four points scale were identified for use as international benchmarks in TIMSS 2003. These included; i) Advance International Benchmark corresponding to a scale score of 625, ii) High International Benchmark corresponding to a scale score of 550, iii) Intermediate International Benchmark corresponding to a scale score of 475, and iv) Low International Benchmark corresponding to a scale score of 400. None of the Ghanaian students reached the first two levels (Advance International Benchmark & High International Benchmark), only two percent reached the third level (Intermediate International Bench mark) with only nine percent reaching the low international benchmark. In the TIMSS mathematics examination, students' reported weakest content areas were geometry, measurement and algebra (Ministry of Education Youth and Sports, 2004a). The question that comes in mind is, why are students' achievements in mathematics so poor, and can research help to improve the situation?

1.3 Personal Context

My quest to contribute to finding answers through research to the problem of poor students learning outcomes in mathematics started when I was posted to a rural Junior Secondary School (JSS) in 1993 to teach mathematics in grades 10,11 & 12 (i.e. JSS1,2&3) after my General Certificate of Education (G.C.E) Advanced level course. Whilst I was teaching I observed that many of the students were very weak in mathematics. Some of them were weak to the extent that they could not even solve some primary school mathematics problems such as long division. I began to wonder why the students were so poor at mathematics because I thought mathematics at that level was quite easy.

I began to look for solutions by first discussing my problem with the few trained teachers at the school. There were only two on the staff. They told me that I should not worry because generally the students were weak, they had poor learning habits and their English ability was low. They pushed all the blame onto the students. I was partially convinced by their explanation because I had already observed that the students' English proficiency level was very low. For most of them, reading the mathematics question alone was a problem. I therefore decided to tackle the linguistic problem and the problem of mathematics content simultaneously by using both the local language and English as the medium of instruction in my mathematics lessons, even though the language policy of Ghana prohibits the use of the local language at that level (JSS level). I also started organising free classes for students after school and began to discipline students who missed classes or who did not do their homework. After all these efforts I still observed that quite a number of students were still very weak in mathematics.

I left in 1994 after one year of teaching in the rural school and took a teaching appointment in an urban primary school in Cape Coast city. Unlike the rural school, the primary four students that I taught at the urban primary school had a very good command of the English language, but some of them were very weak in mathematics. I began to wonder why mathematics which I saw as quite simple was a big problem for students. I began to ask myself questions similar to those raised by Whitehead (cited in MA, 2004) "How can I better help my students to learn?" and "How do I live my values more fully in my practices?" (p.8). I decided to establish a mathematics "clinic" where I identified students who had problems with mathematics and taught them during break time. This solved the problem somehow but I still had some students who had serious problems. After two years of teaching in this school (1996) I decided to enrol in a Bachelor of Education (B.Ed) programme at the University of Cape Coast, in order to equip myself better for my teaching career. I did that because at a certain point I thought the problem might lie in my teaching.

The programme exposed me to new ways of teaching, emphasising the need to arouse and sustain the interest of students throughout my lessons. I saw a number of things wrong with my way of teaching as I went through the programme. I observed that I used a "show and tell" method most of the time. My teaching was also full of drills (i.e. more like military exercise). After the training I worked as a teaching assistant in the Department of Science Education, University of Cape Coast and also as a part time mathematics teacher in some high schools in Cape Coast, Ghana. Whilst I was teaching I still met students who had problems with mathematics. This problem of why mathematics is difficult for students aroused my interest to research into ways of improving student-learning outcomes in mathematics by focusing on teachers and the teaching of mathematics. My focus widened to include the issues of culture in mathematics education when, in the process of collecting data for a research project with Japanese counterparts in 2005, I observed that students do not think at all of sharing in terms of dividing into equal parts (as will be seen in Section 1.4). I saw some sense in their thinking since Ghanaian culture teaches exactly that. I therefore consulted literature on culture and mathematics education (Bishop 1991, Presmeg 1998). It was at this point that I saw how knowledge about the local culture could be helpful in mathematics pedagogy and therefore decided to conduct a study to investigate the influence of culture on mathematics conceptions at primary schools in Ghana.

1.4 Possible Source(s) of Poor Student Mathematics Achievement in Ghana

Several studies have attempted to understand what factors account for the poor performance of students in mathematics (see Annamuah-Menah & Mereku, 2005; Davis & Ampiah, 2005, Davis, 2004). Notable among these factors are the quality of mathematics instruction in primary and junior secondary schools (see Akyeampong & Lewin, 2002; Davis, 2004) and the mathematics curriculum (see Annamuah-Menah & Mereku, 2005). Bishop (1988) highlights the cultural aspect of mathematical knowledge and goes further to suggest the need for mathematics curricula to reflect not only school mathematics but the mathematics within the society as well (as will seen in Chapter Two). However, a cursory look at the primary school mathematics curriculum in Ghana by the researcher revealed that, with the exception of measurement where the curriculum suggests the use of local and arbitrary units before the introduction of the SI unit, and division, the strategy for teaching the other topics in the mathematics curriculum does not clearly show any elements of local culture (Ministry of Education, 2001). Freudenthal (1991) categorises two types of mathematizing as horizontal mathematization and vertical mathematization. According Freudenthal (1991) horizontal mathematization involves movement from the world of life into the world of symbols, whilst vertical mathematization involves moving within the world of symbols. Some of the examples of activities involving horizontal mathematization include transforming a problem in a real life situation to a known mathematical problem, whilst an example of activities involving vertical mathematization includes the use of formula in solving routine mathematical problems. The absence of local aspects of culture in the school mathematics curriculum in Ghana suggests that in the development of concepts, it is possible that the element of horizontal mathematization will be missing in most lessons. A good mathematics lesson must, however, have elements of horizontal and vertical mathematization (see Freudenthal, 1991).

Literature points to the fact that many concepts in mathematics could be influenced by culture (Pinxten & Francois, 2007; Draisma, 2006, Charborneau & John-Steiner, 1988; Saxe, 1988). Examples include number, measurement, shape and space among others. Culturally, societies engage in activities such as counting, which requires the use of number and measurement in the sale of grains, oil and plots of land. Shape and space are used in the description of objects. Students may therefore have ideas about these concepts before they are taught in the classroom. Their prior knowledge about these everyday occurrences may therefore influence their concept formation in mathematics. In Ghanaian society for instance shapes that are close to that of a circle are described as being circular ("Kokroba" in the Fante language). Thus, there is no distinction between oval and circle. Also, culturally Ghanaians do not distinguish between plane shapes and solid shapes. Square/rectangle and cube/cuboids are all described as "adakaba" meaning box. All these elements of culture may influence the formation of the concept of geometry for example. A look at students' areas of weakness in the TIMSS 2003 mathematics examination (Ministry of Education Youth and Sports, 2004a) and the survey conducted by CRIQPEG in the three

Northern Regions of Ghana in 2005 (Duedu, Atapka, Dziyella, Sopke & Davis, 2005) reveals that almost all the content areas indicated as weaknesses of students, with the exception of algebra, have some bearing on the local culture. The question therefore is, could this not be a good reason for studies into how the local culture could serve as a source of constraints/affordances in the development of some of these mathematical concepts in Ghana?

Studies have revealed that some basic school teachers use the lecture method to transmit mathematical knowledge to students, even at the lower primary level (see Davis, 2004). In his study on the provision of quality primary and junior high school education in Ghana, Ampiah (2008) found the use of "inappropriate teaching methods" (p.35) in all subjects, including mathematics, as one of the factors hampering the provision of quality education in Ghana. It is becoming increasingly evident that most communicators of mathematical concepts in Ghana are ignorant about the influence of the local culture on mathematical concept formation. According to Skemp (1987), in communicating mathematical concepts, the communicator of the concept has to give students some experiences for them to abstract the common property. The experiences in this case may be drawn from the environment and therefore may have some cultural relevance to the learner.

A lesson on fractions observed by the researcher in a Primary four class in the Central Region of Ghana in February 2005 revealed that students do not think at all of sharing in terms of dividing into equal parts. This was revealed when the teacher asked a student how she was going to share a loaf of bread with a brother. The student in answering the teacher's question responded that she would divide the loaf of bread into three and then give the brother one out of the three parts. Culturally her response was right in the sense that in the Ghanaian culture (like other cultures in the world), sharing does not necessarily mean sharing equally; it depends on a number of factors such as who is the eldest. Thus the student's response to the teacher's question is an indication that she is older than the brother. Cultural elements such as this may in one way or another influence the formation of mathematical concepts at the primary school level in Ghana. However, studies that have been conducted on cultural influence on the formation of concept of operation on numbers, for example in African contexts similar to the Ghanaian situation, have shown clearly that students come to school with rich experience from their cultures which have the potential to support their understanding of concept formation (see Draisma, 2006).

In this section, lack of cultural relevance to the school mathematics curriculum and mathematics pedagogy was generally highlighted as possible source(s) of students' poor achievement in mathematics. In the next section a description of the problem that this study sought to explore will be provided.

1.5 Statement of the Problem

The problem of the mathematics curriculum, which has often been described by some Ghanaian researchers as old fashioned (see Annamuah-Mensah & Mereku, 2005), and the quality of instruction are serious issues in Ghana. It is against the issues of students' poor achievements in mathematics generally, and fractions and measurement specifically, coupled with the problem of the mathematics curriculum, and the quality of instruction, that a research study on cultural influences on primary school students' mathematics conceptions in Ghana is very important, at least to draw stakeholders' attention to the need to use students' culture as an asset in mathematics pedagogy in school.

Number, measurement and shape, which were identified as being problematic for school children in Ghana, are all deeply rooted in the Ghanaian culture. Counting using body parts (fingers) in local languages is very common in the Ghanaian culture. The Ghanaian system of number labelling in Fante language, for instance, makes clear its base-ten structure even between ten to twenty similar to base-ten structures pertaining in other cultures such as the Japanese culture (see Saxe, 1988). As in other cultures in Africa (see Draisma, 2006), simple operations such as addition and subtraction are done with the fingers in the Ghanaian culture. Ghanaian local market women who have never been to school use a system of counting similar to base five, and name twenty groups of five “Oha” (hundred in English). They also use a system of counting of money (Pon) that is very similar to multiples of two. “Pon du” in the Fante dialect for instance means twenty. “Du” in the ordinary Fante language means ten but the “pon” (which originated from the British Pound Sterling) that precedes the ten connotes that the value should be doubled (this was because the exchange rate of the British Pound to the Ghanaian Cedi after independence i.e. in 1967 was one Pound to two Cedis). In Ghana the local market women are still using this system of money counting long after Ghana's independence and the system supports counting up to any value. Even though students know the concept of “Pon” and counting by fives, they struggle to memorise the two times and the five times tables in school. Measurement in the traditional Ghanaian culture is similar to others in Africa (see Takuya, 2003) and involves the use of arbitrary units. Even today grains such as rice and beans are measured in most Ghanaian local markets using empty tins such as margarine, tomato or milk. Lengths are usually measured using arbitrary units such as stretch of the arm, spans and so on. Local geometrical shapes such as “adinkra”, which are used as designs in the local Ghanaian fabrics, are some of the shapes that are referred to as regular and irregular shapes in the formal mathematics classrooms. It is evident that the content areas (number, measurement and shape) which were mentioned as being problematic to children are areas students have much prior knowledge of through their cultures. Unfortunately, however, gaps continue to exist between some of the mathematical practices that exist in the Ghanaian society (OOSM) and those that take place in school (ISM) (as will be seen in Chapter Two). There appears to be a mismatch between some of the mathematics that exists in the society and some that exists in the school curriculum. This mismatch may have the tendency to influence mathematics pedagogy, as well as students’ mathematics conceptions and practices in school.

The language of instruction in mathematics in Ghanaian schools from grade four onwards and the language of mathematics textbooks (even from grades one to three where the medium of instruction is mainly in the local language) continue to remain in the English language (students’ second/weakest language). These issues on language use also have the tendency to influence students learning outcomes in mathematics, as literature suggest that language plays a crucial role in mathematics pedagogy (Setati, 2005a; Durkin, 1991). Studies that have been conducted with bilinguals in contexts which were not very different from the Ghanaian situation have shown that elements of local culture do influence students' interpretation and strategies in mathematics word problem solving, for example (Leap, 1988; Spanos, Rhodes, Dale & Crandall, 1988).

Many studies have been conducted in Ghana to find out the causes of students' poor performance in mathematics. Unfortunately none of these studies, to the best of the knowledge of the researcher, has been conducted to look at the influences of the local culture on school children's mathematical conceptions and practices in school at the primary school level. This is probably due to the fact that many mathematics educators and researchers in Ghana still hold the view that mathematics is culture-free (due to the influence of a mathematics curriculum which was handed down to Ghanaians by the British colonial masters during the colonial era). This view, however, is not tenable, since several researchers have pointed to the fact that values and the local culture play a role in mathematics teaching and learning (Presmeg 1998; Seah, 2004). It is against this background that this study was designed to research into the problems associated with developing sociocultural approaches to mathematics teaching and learning in Ghana. Primary school level remains the level where students are expected to acquire the foundation to study mathematics at the higher levels of education, hence the researcher's choice of primary school level as a focus for this study.

1.6 Purpose of the Study and Importance of the Study

1.6.1 Purpose of the Study

Bearing in mind these points, the purpose of the study is to explore students' transition experiences (including how they experience mathematics between home and school contexts) and also the extent to which elements of the Ghanaian culture such as customs and language influence students' formation of concepts of fraction and measurement at primary school level in Ghana. The study will also explore the level of teachers' and headteachers' awareness of the role of local culture in mathematics education as well as their views about the nature of mathematics. In addition, the school(s) of thought that influence(s) mathematics education in Ghana will be investigated by looking at the planned curriculum. This will enable the researcher to ascertain stakeholders' views about the nature of mathematics. The researcher finds it necessary to ascertain the views of subjects about the nature of mathematics since studies have shown that learners' beliefs about the nature of mathematics affect what mathematics they identify as mathematics in out-of-school settings (Civil, 2002; Masingila, 2002; Presmeg, 2002). This therefore has a major influence on the success of any attempt to bridge in-school and out-of-school mathematics in any setting (i.e. to develop a sociocultural curriculum).

The following focus questions will guide the study:

1. In what ways does Ghanaian culture influence the formation of the concepts of fraction and measurement?
2. Are headteachers, teachers and students aware of the mathematics within the Ghanaian culture?
3. What transition experiences do primary school students go through in their mathematics learning as they move between the home and the school every day?

4. Are the headteachers and teachers aware of the supports culture could lend to the teaching and learning of mathematics?

1.6.2 Importance of the Study

The findings of this study have the potential to challenge the current school of thought that guides mathematics education in Ghana and inform policy and pedagogical practice accordingly. Such information will be crucial at this moment especially when Ghana is trying to re-orient her mathematics and science education to meet international standards.

Teachers in Ghana particularly will find this study useful because it will help them to identify some of the elements of Ghanaian cultural practices that influence students learning and to fashion their lessons in such a way that those influences support students understanding of classroom discourses rather than interfering. This will enable students to easily make connections between school mathematics and the mathematics they encounter in their daily lives. This will go a long way towards improving students understanding of mathematics and hence their achievement in mathematics. In the final Chapter, a three stage model will be proposed to help teachers to gradually expand students' schema of mathematics to include school mathematics.

To the research community in Ghana, this study will be useful in the sense that literature on the influence of Ghanaian culture on mathematics conceptions is, to the knowledge of the researcher, non-existent. This study will therefore contribute to literature about the influence of culture on mathematics conceptions and its possible effect on students' learning outcomes in Ghana in particular and other multicultural societies in general. Some of the issues that emerge from the study may generate further research and dialogue in Ghana particularly and other multicultural societies generally. Policy makers, researchers and teachers from other African countries and the developed countries that host many foreign immigrants will also find this study as a useful source of literature.

To the researcher, this is a new area. The literature gathered through this research will deepen his understanding on issues relating to sociocultural influences on mathematics learning. The experience gained through this thesis preparation will sharpen the research skills of the researcher. This will enable him to contribute effectively to research in mathematics education generally and in Ethnomathmatics specifically, especially in Ghana, where the concept of Ethnomathematics is still very new. In the final chapter the ideas about the implications of the study will be presented and discussed.

1.7 Terminology

In order to ensure that readers understand the context within which certain key concepts have been used, the following definitions to each of the key concepts used in this study are offered.

- ***Basic school*** as used in this study consists of students from grades 1-9 (i.e. students in primary and junior secondary/high school). (My interpretation for this study)
- ***Culture*** as used in this study refers to the complex of shared understanding which serves as a medium through which individual human minds interact in communication with one another (Bishop, 1988).
- ***Curriculum*** as used in this study encompasses the aims, content, methods and assessment procedures but not to syllabus (Howson, Keitel & Kilpatrick, 1981).
- ***Formal approach to mathematics*** as used in this study refers to approaches that are linked to school practices, often seen in textbooks. (My interpretation for this study)

- ***Gross Enrolment Ratio (GER)*** as used in this study refers to the total enrolment of students in primary school, regardless of their age, expressed as percentage of population of school age children in Ghana. (My interpretation for this study)

- ***Informal approach to mathematics*** as used in this study refers to the approaches that are linked to out-of-school/home practices. (My interpretation for this study)

- ***In-school mathematics*** refers to western/international mathematics which the child usually acquires through formal schooling. (My interpretation for this study)

- ***Out of school/everyday mathematics practices*** as used in this study refers to mathematics practices experienced in everyday life which may not be the same as school/western mathematics. This knowledge constitutes knowledge acquired through cultures as the child grows. (My interpretation for this study)

- ***Performance*** as used in this study refers to grade/score obtained by students in any examination(s) conducted by any organisation/group of experts recognised by the Ghanaian system as credible enough to assess the attained curriculum. These therefore include students' scores/grades in Performance Monitoring Test (PMT) conducted by Ghana Education Service (GES), Basic Education Certificate Examinations (BECE) conducted by the West African Examinations Council, Trends in International Mathematics and Science Study (TIMSS) conducted by IEA and other examinations conducted by teams of experts for research purposes. (My interpretation for this study)

- ***Sociocultural curriculum*** as used in this study refers to a curriculum that encompasses not only those experiences that take place within schools, but the entire scope of experiences both within and outside school, as well as values. (My interpretation for this study)

- ***Sociocultural teaching*** as used in this study refers to the teacher's ability to use his/her knowledge in mathematics to support students to create their shared meaning of the concepts she/he is teaching by ensuring effective communication between teacher-students, student- student and student-teacher. By this the teacher does not just dispense an organised body of materials, showing and telling students how to use certain methods to arrive at answers hoping that students will internalise the material in the form presented to them. Rather, through effective communication, the teacher makes use of children's experiences both within and outside the classroom, helping students to clarify their understanding of pre-requisite ideas before guiding them from their present understanding towards the new one. Thus in sociocultural teaching as used in this study; the teacher is more of a facilitator of learning rather than dispenser of knowledge. (My interpretation for this study, see also Steele, 2001)

1.8 Organisation of the Study

In this chapter the researcher has provided the demographics of Ghana, highlighting the various tribes and the languages used in the country as well as the formal education in the country. In the statement of the problem, the researcher has also discussed the problem of students' poor performance in mathematics in the context of Ghana and the fact that almost all the topics that are often cited as being problematic to students such as fractions and measurement are the very topics students have much prior knowledge of. The researcher's personal context in relationship with the research, the purpose and the significance of the study as well as the definition of key terms used in the study have also been discussed in this Chapter. The organisation of the rest of the study is presented in the next two paragraphs.

In Chapter two a review of theories used to illuminate the problem and previous research related to the study will be presented. Thus in this chapter three theoretical lenses that were drawn to support the study will be discussed .These are theories and research supporting mathematics as a cultural object, socio-cultural theories of learning and their application in research, and children's transitions between home and school contexts. The Chapter ends with the research questions for the study.

The methodology the researcher planned to use for the study, namely the research approach including the design, research participants, various data sources and their relationship with the research questions presented in chapter two, Data analysis procedure and their relationship with research instruments will be presented in Chapter three. The implementation of the planned research methodology discussed in Chapter three will be presented in Chapter four. In Chapter four, therefore, how the whole research procedure in Chapter three was implemented will be presented.

In Chapters five and six results of the study will be presented, whilst in Chapter seven results from Chapters five and six will be merged in a discussion that ranges across the schools in order to address the research questions posed at the end of Chapter two. In Chapter eight the conclusion and implications of the study will be drawn from discussion of findings in Chapter seven, and in relationship to the problem outlined in Chapter one.

Chapter Two – Theories and Previous Research

In this chapter the researcher will draw on three theoretical lenses to illuminate the problem. These are the cultural nature of mathematics (D' Ambrosio, 1999, 1985; Bishop, 1988; Gerdes, 1999, 1994, 1988), socio-cultural theory on how children learn as purported by Vygotsky (1934/1987, 1978), and school children's transitions between contexts of mathematical practices (Abreu, Bishop & Presmeg, 2002). As the whole thesis is designed to investigate cultural influences of students' thinking and practices in mathematics, these theoretical lenses are important for the study. In the first, Bishop (1988) positions mathematical knowledge and mathematics curriculum as cultural objects, whilst in the second Vygotsky also highlights the cultural aspects of pedagogy. Ghanaian students move between contexts of mathematical practices in the society/home (OOSM) and the schools(ISM) (as will be seen in Section 2.3); this movement is likely to also influence their conceptions and practices in mathematics in school. Hence, Abreu, Bishop and Presmeg's theory on transitions between contexts of mathematical practices also becomes important in this study. The chapter ends with a summary of the general research questions/issues and subsidiary questions reflecting aspects of each of the main issues, to guide the study.

2.1 Mathematics as a Cultural Object

As discussed in the previous chapter, researchers are now pointing to the fact that Mathematics, which was once regarded as culture and value free, is no longer regarded as such (Barton, 1996, 1998; Bishop, 1988; D'Ambriosio, 1999, 1985; Gerdes, 1999, 1994, 1988; Owens, 2001, 1999; Presmeg, 1998;). Views about the nature of mathematical facts being absolute and unquestionable have changed in recent times (Pinxten & Francois, 2007). Mathematical knowledge has a strong social component since it is considered as objective knowledge that can be subjected to proofs as well as criticisms (Presmeg, 2007). According to Presmeg (1998) in the last few decades, many writers in the ethnomathematics movement have argued that, "mathematics is a cultural product which needs to be acknowledged as such in classroom both for the purpose of meaningful learning of the subject in developing countries …" (p.320). Presmeg suggests that culture of both pupils and the teacher could be a useful tool in mathematics teaching and learning. Other researchers are also of the view that successful study of mathematics must take into account the many and varied experiences with which children come to school (Charborneau & John-Steiner, 1988).

For most countries that were colonised some of the things that accompanied colonisation such as religion, have been contextualised, but in most cases not mathematics education. A look at the nature of church services in Christian churches (especially in African Initiated Christian Churches) in most African countries in general and Ghana specifically today, for instance, show that the nature of service has been shaped by the local culture. Literature in this area shows that the Bible is read with an African cultural background rather than western cultural background (Lettinga, 2000). Today one can see local drums, hear local gospel music other than the orthodox songs being sung during worship services. Christianity in Africa today has witnessed a very fast growth rate as a result of its being contextualised.

The same however cannot be said about mathematics education after independence, even though both western mathematics and Christianity came together through the introduction of formal education during the colonial era. In situations where policy even emphasise the need to include cultural dimensions into mathematics education, the will to execute it through school curriculums is absent (Kaleva, 2004). The researcher suggests that this is probably because some developing countries still hold the notion that mathematical truth is absolute.

Bishop (1988) asserted that "mathematics must be understood as a kind of cultural knowledge, which all cultures generate but which need not necessarily 'look' the same from one cultural group to another" (p180). He further postulates six fundamental activities which appear to be carried out by all cultural groups that have been studied and are also necessary and sufficient for the development of mathematics. These activities are:

> Counting: The use of a systematic way to compare and order discrete phenomena. It may involve tally, or using objects or string to record, or special number words or names ....;
>
> Locating: Exploring one's spatial environment and symbolising that environment, with models, diagrams, drawings, words or other means ....;
>
> Measuring: Quantifying qualities for the purposes of comparisons and ordering, using objects or tokens as measuring devices with associated units or 'measure-words'....;
>
> Designing: Creating a shape or design for an object or for any part of one's spatial environment. It may involve making the object as a 'mental template', or symbolizing it in some conventionalised way ....;
>
> Playing: Devising, and engaging in, games and pastimes, with more or less formalised rules that all players must abide by ....;
>
> Explaining: Finding ways to account for the existence of phenomena, be they religious, animistic or scientific....
>
> [To a naturalist like Alan Bishop] Mathematics, as cultural knowledge, derives from humans engaging in these six universal activities in a sustained, and conscious manner (Bishop, 1988, pp. 182 -183).

It is clear from the standpoint of the naturalist that all cultures create their own mathematics by engaging in activities such as counting, measuring and designing. However some individuals and even societies undervalue some of the mathematics within cultures or assign more value to some of the mathematical practices within some cultures more than in others (Abreu, 1993; Abreu, 1995). Presmeg (2007) refers to the former situation as “historiography” and the later as “valorization”. According to Premeg (2007), historiography looks at “some of the world's mathematical systems that have been ignored or undervalued in mathematics classroom [whereas] valorization is the social process of assigning more value to certain practices than others" (pp. 441-443). Literature has shown that most children deny the existence of, or devalue mathematics as used in practices which they encounter within out-of-school settings (Abreu, Bishop & Pompeu, 1997; Abreu & Cline, 1998). This issue is critical in any future attempt to implement meaningful mathematics education in a developing country like Ghana, especially in the implementation of a mathematics education programme that ensures the bridging of the gap between in-school and out-of-school mathematics (as in the development of sociocultural curriculum for example). Stakeholders' notions of the value of out-of-school mathematics within the Ghanaian culture will determine their willingness to use it to support the development of in-school mathematics in the classroom setting. Presmeg (2007) asserts that until Abreu's (1993, 1995) research raised this topic (valorization), "the value of formal mathematics as an academic subject was for so long taken for granted that it became a given notion that was not culturally questioned" (p.443). Presmeg further asserts that "if ethnomathematics as a research program is to have a legitimate place in broadening notion of what counts as mathematics and of which people have originated these forms of knowledge, then issues of valorization assume paramount importance" (p.443). This study will contribute to the literature on valorisation by investigating what counts as mathematics to students, teachers and headteachers in Ghana (as will be seen in Section 2.4). It was evident from the literature that has been reviewed so far in this Chapter that a growing body of literature has shown that mathematics is neither culture free nor value free. In the next section literature on cultural aspects of mathematics curriculum will be reviewed.

2.1.1 Mathematics Curriculum as a Cultural Object

Literature points to the cultural nature of the mathematics curriculum (Barton, 1996, 1998; Bishop, 1988; Gerdes, 1999; Howard & Perry, 2005; Owens, 2001, 1999; Seah, 2004). Bishop (1988) after analysing five approaches to curriculum by Howson, Keitel and Kilpatrick (1981) namely the Behavourist Approach, New-Math Approach, Structurist Approach, Formative Approach and Integrated-Teaching

Approach proposed a sixth approach as Cultural Approach to mathematics curriculum. He postulates five characteristics of enculturation curriculum or the cultural approach to mathematics curriculum as:

Firstly, representing the mathematical culture, in terms of both symbolic technology and values; Bishop (1988) identified rationalism and objectism as a complementary pair of ideological values in Mathematics; control and progress as a complementary pair of sentimental values (values relating to beliefs about Mathematics); and mystery and openness as a complementary pair of sociological values, which according to Bishop "concern relationship between people, and within social institutions, in relation to Mathematical knowledge" (p.75).

According to Bishop, rationalism relates to the use of logic and reasoning in achieving explanations and conclusions in Mathematics, and it involves the use of logic, completeness and consistency. Bishop argues that appreciation of rationalism requires making children aware of explaining, of abstracting and of theorising. Whilst objectism relates to the treatment of abstract entities as if they are objects, an example includes the treatment of irrational and imaginary numbers. Bishop further explains that "rationalism emphasises the logic of reasoning but objectism gave mathematics the intuitive basis for the 'atoms' of argument" (p.68).

According to Bishop, progress relates to feeling of growth and, of development. This value is associated with the feeling that the 'unknown' in Mathematics can be known. Bishop argues that progress is associated with the recognition and valuing of alternatives. Control on the other hand is the feeling that is associated with the power of Mathematics in explaining aspects of both the natural and man-made environment. It also relates to the feeling of control and security when a learner understands Mathematics.

According to Bishop, openness espouses the value that Mathematical truth is open to verification by all. Bishop explains that "with rationalism as an ideology and progress as the goal, individuals are liberated to question, to create alternatives ..."

(p.76). Mystery is a value associated with the mystery surrounding what Mathematics is and those who generated them.

Thus the first characteristic of the enculturation curriculum emphasises the need to attend explicitly and formally to all values (discussed above) of the mathematical cultures, most especially the need to pay attention to values such as rationalism, progress and openness. Whilst this study is not mainly on values in mathematics, the review of the values becomes significant in the next five paragraphs, where the researcher argues for the need to take these values into consideration in assessing students' mathematics learning outcomes.

The second characteristic is objectifying the formal level of culture of Mathematics. Here the emphasis is on the connection between the formal level of mathematics and the informal level of mathematics and their link to the technical level of Mathematics (as in pure Mathematics). The curriculum must reflect connection between Mathematics and present society as well as mathematics as a cultural phenomenon. Preparation for technical level of Mathematics is not the main aim of this curriculum. The structure used in the development of Mathematical ideas and concepts is to be based on the six universal activities described in Section 2.1 above. According to Bishop, as Mathematics is part of learners' culture, it will be important to reflect that cultural basis in the structure of their Mathematics curriculum. This point becomes more significant to this study when we consider mathematics in Ghanaian society (see Section 2.1.2).

The third characteristic is being accessible to all children. Here the emphasis is on the need for a Mathematics curriculum to be designed to meet the learning needs of all learners, not just for a few who want to pursue mathematics at higher levels. This is reflected in Bishop's assertion that "Enculturation must be for all" (p. 96). Thus the 'top-down' approach (as described by Bishop) does not help students who either do not wish, or who are unable to go on to further mathematics. This curriculum must however take cognisance of individual differences in learners and therefore provide opportunities for them to pursue certain ideas further than other children based on their interest and background. Related to this issue of accessibility is the fact that the curriculum content must not be beyond the intellectual capabilities of the children, nor must the material examples, situations, and phenomena to be explained be exclusive to any one group of the society. Thus the choice of what counts as mathematics to be included in school curriculum and also the need to create curricula structure to cater for individual needs of children becomes important here.

The fourth characteristic is emphasising mathematics as explanation. Here the emphasis is not primarily on doing, with very little emphasis on explaining, but on explaining as well. Bishop asserts that mathematics as a cultural phenomenon derives its power from being a rich source of explanations, and that feature must shape significant understanding to emerge from the enculturation curriculum. According to Bishop, the power of explanation will only be conveyed if the phenomena-to-be explained are accessible to all children, and are 'known' by them but remain unexplained. He asserts further that both physical (natural and man-made environment) and social environments constitute the source of such phenomenon. The need for the mathematics curriculum to be based in the child's environment and the child's society is the message here.

The fifth characteristic of enculturation curriculum is being relatively broad and elementary rather than narrow and demanding in its conception. Here Bishop asserts the need for a variety of contexts to be offered since the power of explanation, which is derived from Mathematics' ability to connect unlikely group of phenomena, needs to be fully revealed. He argues that the constraint of a finite time for schooling means that, if breadth of explanation and context is to be an important goal, then Mathematics content must be relatively elementary. Here he does not propose merely simple arithmetic content or Fun Maths or only childish games. The basis of his argument is that if 'enculturation' is the goal and 'explanation' is the power of the symbolic technology of the culture, then undue complexities in that technology will fail to explain, fail to convince and therefore ultimately, fail to enculturate. The message here is that a good enculturating curriculum must take cognisance of explanation and context in its structure and this has implications for the nature of mathematics content to be taught. According to Bishop these attributes of enculturating curriculum are very important in the education of all manner of children including future mathematicians (extracted from Bishop 1988, pp. 95-97).

Much as the researcher agrees with all the issues raised by Bishop on ‘cultural’ curriculum, most especially with his emphasis on the connection between the formal level of mathematics and the informal level of mathematics and their link to technical level of Mathematics, the issue of examination may be problematic in some developing countries such as Ghana. Two reasons may account for the researcher’s position on the assessment. Firstly, the fact that in the Ghanaian society healthy competition is emphasised as a desirable trait within education, it may therefore be difficult to look at assessment and examination from Bishop’s perspective in the present Ghana. Secondly, most Ghanaian students study very hard when they are aware of competition.

Since different societies require different ways of addressing their problems at each stage of their growth, examinations should still be an important aspect of the school curriculum but must reflect the values prescribed in the ‘culture’ curriculum (emphasising especially rationalism, openness and progress), as much as possible. Consideration of these values therefore requires alternative means of assessment where different criteria would be used to assess the abilities of different groups of students, based on their background and their learning needs. By so doing the process of enculturation will benefit all. This may reduce the large number of students who are unable to cope with school Mathematics as it pertains in developing countries like Ghana where the mathematics curriculum has been often criticised as being old fashioned (Annamuah-Mensah & Mereku, 2005). The current Ghanaian curriculum in the researcher’s opinion does not pay much attention to the role of culture in the process of enculturation (as already noted) (Ministry of Education, 2001), even though there are a great many rich mathematics activities in Ghanaian society which could be drawn upon (as will be seen in Section 2.1.2 below).

Ethnomathematics researchers have argued for a difference between mathematics encountered in the local culture/society and school mathematics (Bishop 1988; D' Ambrosio, 1985). Bishop (1988) for instance argued for a difference between "m" mathematics (encountered in the local culture/society) and "M" Mathematics (the western/international mathematics). Bishop further described two types of mathematics education as being enculturation and acculturation. According to Bishop, Mathematics education as an enculturation process has to do with inducting the child in practices which constitute part of the child's own culture, whereas acculturation has to do with the process of inducting the child in mathematical practices which are alien to the child's culture. Based on this categorisation, one can deduce from the argument made in Section 1.5 regarding the mismatch that appears to exist between the Mathematics in school curriculum and the mathematics in the Ghanaian society that Mathematics education as it pertains in Ghana at present looks to be more acculturation than enculturation. We will now turn to mathematics in Ghanaian society in the next section.

2.1.2 Mathematics in Ghanaian Society

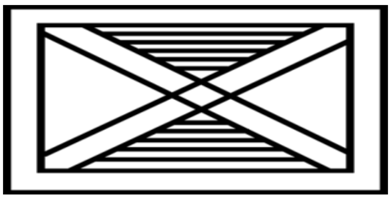
As already noted in Section 1.5 there are numerous mathematics practices in Ghanaian society. My argument concerning mathematics in Ghanaian society will be based on the six fundamental activities proposed by Bishop (1988). These are both universal and appear to be carried out by all cultural groups that have been studied, and are also necessary and sufficient for the development of mathematics to highlight some of the mathematics within Ghanaian society. The researcher wishes to emphasise that in most cases a number of mathematical activities are embedded in one activity. It is possible, for instance, for a learner to be taught both measurement and shapes in the process of designing an item (e.g. a dress). In other words, it is rare to find somebody just learning to measure for the sake of it. Learning (in out- of-school context) in Ghanaian society is mainly contextual in nature. A dressmaker for instance will teach an apprentice how to measure during the process of designing a dress. The dressmaker will not teach the apprentice how to measure at one time and how to apply the measurement skill in designing at another time. The researcher's explanation of mathematics in Ghanaian society will include counting, locating, measurement, design and games. Explanation of all the activities listed above and other phenomenon are usually done by means of verbal and gesture explanations.

To start with, the counting system in twi language, which is shared by the Akans in Ghana, make clear its base ten structure even between ten to twenty. Ten in the Fante dialect (which is one of the dialects spoken by the Akans), for instance, is “du”, eleven is “du biaku” which means “ten and one”, twelve is “du ebien” which means “ten and two”, and so on. A considerable amount of arithmetic also goes on in Ghanaian society. Examples include the system of counting by some markets women which is based on multiples of two, and the use of arithmetic by children who sell candies, newspapers, cold drinking water and oranges in both rural and urban areas. These children (both schooled and ‘unschooled’) engage in the process of doing and explaining the arithmetic they go through in order to arrive at the total cost of items a customer purchases.

Locating is also a common mathematical practice that is carried out in Ghanaian society. Through the use of gestures and verbal explanations people explain the location of different objects and places. It is possible for an ‘unschooled’ person for instance to describe the location of a car park, for example using vocabulary like turns, right, left, straight, north and south.

Measurement is yet another mathematical practice in Ghanaian society. Ghanaian market women make use of empty tins as a unit of measurement, especially in the sale of grains and chilli among others (see Appendix A). It may be possible for most Ghanaian rice sellers, for instance, to tell the number of empty margarine tins (see Appendix A02) full of rice which make one bag of rice. Liquids such as oil, for example, are usually measured using empty bottles. Thus some of these empty bottles are used as units of measure all over the country. It is very common for market women, for instance, to tell the number of beer bottles of oil in one 4.5 liters gallon container. The use of the stretch of arms in the measurement of length is also very common. Measurement of time using the sun’s position in the day and the crow of the rooster is also common. Hence, measurement is carried out very much in the Ghanaian society.

Designs, especially the local designs used in Ghanaian fabrics such as the “adinkra” (see Figure 2.1 below), are very good examples of some of the regular and irregular shapes that students’ experience in school. "Adinkrahene" for instance could be used in the introduction of the concept of concentric circles. The patterns in “Kente”, traditional Ghanaian clothing usually worn by traditional rulers (see Figure 2.2), is similar to the patterns in the twil weaving which Charinder (2002) used in her research on cultural activity in mathematics. Literature suggests that there are a number of rich mathematical concepts embedded in the Akan Kente weaving patterns (K, 2010). The architectural design used in building the round houses in northern Ghana, for example, has a large number of geometric shapes. The roof has the shape of a cone while the house is cylindrical in shape (see Appendix B). In farms, the mounds in which farmers cultivate yams have the shape of a cone. Also the cultivation of coconut usually follows a pattern. Farmers usually keep constant intervals between the trees. This can be used in the process of teaching series, for example.



Name: MFRAMADAN

Interpretation: Wind resistant house

Meaning: symbol of fortitude and readiness to face life's vicissitudes

Name: ADINKRAHENE

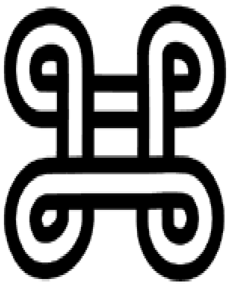
Interpretation: Chief of the adinkra symbols

Meaning: symbol of greatness, charisma and leadership

Name: FAWOHODIE

Interpretation: Independence

Meaning: symbol of independence, freedom, emancipation



Name: MPATAPO

Interpretation: knot of pacification/reconciliation

Meaning: symbol of reconciliation, peacemaking and pacification

Figure 2.1. Collection of some Adinkra symbols and meanings in Ghanaian society (source: Arthur, 2001).

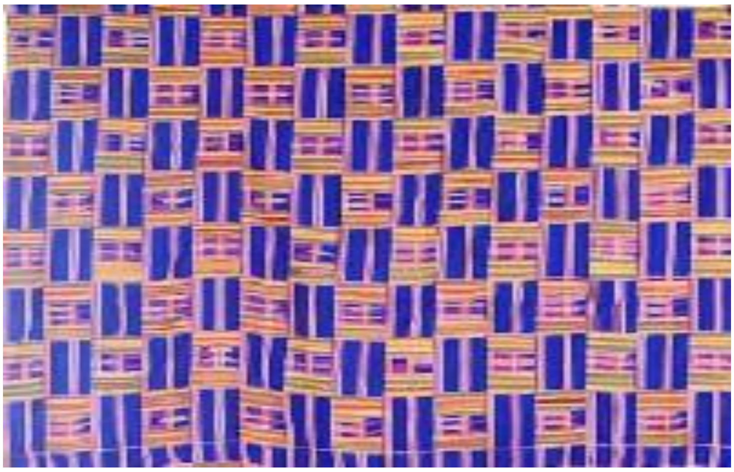


Figure 2.2. Visual Expression - Kente weaving (source: Stockton, n.d.).

Games are yet another source of mathematics in Ghanaian society (see Anamuah-Mensah, Anamuah-Mensah & Asabere-Ameyaw, 2009; Zaslavsky, 1973). Some of the games in the Ghanaian society such as “Oware”, “Draught” and “Tumatu” are good example of games that may be useful in developing a number of mathematical concepts and also prepare children for problem solving in mathematics. “Tumatu” for example could be used to develop the concept of addition (adding on). Figure 2.3 shows the diagram of the "Tumatu" game. This diagram is drawn on the floor. The game usually involves two or more people with players usually stepping in each of the regions starting from A on one leg to pick an object the player drops from O into the regions in a systematic manner. The winner of the game is the one who wins more of the regions numbered A to I. From this game it may be possible to draw a child's attention to the fact that to find the total number of regions to be covered in order to get to region G, for instance, while the child is already in region C, the child could get the total number of regions by counting on from where the child is (i.e. C) instead of counting all from A. In this case the child will add the remaining four regions (D, E, F and G) on the three to get seven regions as the answer. This may help them to develop the concept of adding on in the learning of the concept of addition.

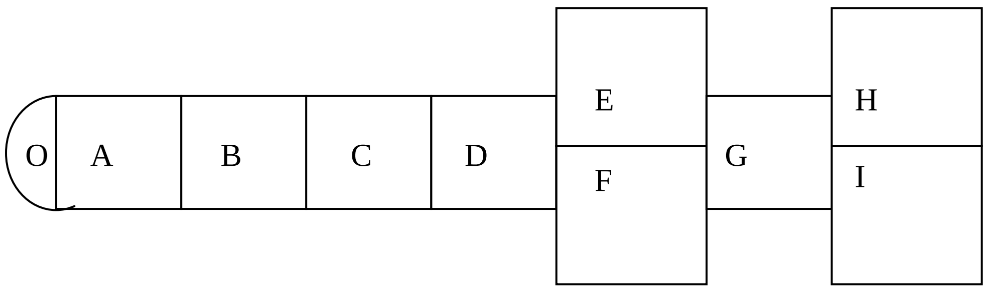


Figure 2.3. “Tumatu” game.

Also musical games such as “bodambo” (i.e. bottle in English) could also be used to help children to understand the concept of adding on. In this game participants sing the ‘bottle’ (“bodambo”) song, saying in the song there is one bottle standing on the top of a building, so if you add one to this bottle what will the total be? The participants would respond in the song there would be two bottles on the building; the participants will continue to add one on to the previous answers. The same game could be used to help students to learn how to add on numbers other than one.

From the discussion so far on mathematics in Ghanaian society it is clear that there are numerous culturally relevant potential approaches to mathematics within the Ghanaian society, all of which could be usefully employed by teachers in the classroom. Although Martin et al (1992, p. 89) have proposed activities involving the use of draughts in teaching arithmetic in pre-services teacher training in Ghana, a look at the teaching strategies proposed in the primary school mathematics syllabus in Ghana generally pays very little attention to the use of these out-of-school mathematics in mathematics learning in school (Ministry of Education, 2001). In most cases concrete materials from the environment (including cultural artefacts) are used in only primary one and two, as in the case of measurement for example (Ministry of Education, 2001, pp.13-15, p. 30). This may be due to the influence of constructivist theories that play down the role of culture in concept formation and rather create the notion that children need these materials only when they are operating at certain levels (concrete abstraction) of development (Sutherland, 1992). If the aim of mathematics education is to help people to use mathematics efficiently within the society, then the issue of what counts as mathematics to be learnt in schools should be looked at carefully.

Literature suggests that some of these culturally relevant approaches to mathematics are not peculiar to Ghana alone but to many sub-Sahara African countries (Gerdes, 1999, 1988; Zaslavsky, 1973). Zaslavsky (1973) for instance has said that "if one wanted to survey the whole field of geometric design in Africa, one would have to catalog almost every aspect of life, from commerce to courtship" (p.174).

In this section the researcher has described how mathematically rich Ghanaian society is, but the question is, are these rich out-of-school mathematics in Ghanaian society efficiently employed by teachers to scaffold students' understanding of mathematics in school? In the next section the researcher will review literature on cultural aspects of mathematics concept formation.

2.1.3 Mathematics Concepts as Cultural Objects

This section looks at some of the literature on concept formation in mathematics generally and concept formation in fractions and measurement specifically. In this section the researcher also argues about the fact that these concepts are cultural objects. Concepts of measurement and fractions were chosen because, apart from being identified as problematic topics (as was seen Section 1.2), a number of ethnomathematics researchers have looked at issues of culture in mathematics at the initial cultural interface such as locating but not much has been done on actual mathematical practices.

2.1.3.1 Mathematical concept formation.

Mathematics education researchers have addressed the issue of mathematics concept formation from different perspectives. In this section we will look at two of those that have relevance to this study namely Skemp's (1987) and Burn's (1992) explanation of concept formation in Mathematics. Skemp (1987) emphasises the need to provide children with known experiences in the process of mathematical concept formation. Skemp explains further that it is possible, for example, to teach Ghanaian students the history of Europe before the history of Ghana without the students having problems understanding these two areas, but in mathematics the situation is very different. Students will find the concept of algebra very difficult if their knowledge in arithmetic is very weak.

Burns (1992) stresses the importance of children's experience in the real world in the learning of mathematical concepts. He explains further that children attain equilibrium when their understanding is based on reality rather than perception, and that there is a continuous interaction between mental conceptual structures and environment at the state of equilibrium. The implication here therefore is that children's previous experiences play a vital role in the successful formation of mathematical concept. Burns (1992) further suggests three other factors that influence students' mathematics learning as maturity, physical experience and social interaction and "process of equilibrium coordinates these three factors" (p.28).

A study of the literature by Skemp and Burns shows that even though both mentioned the need for previous knowledge in the process of concept formation, the former's explanation of prior knowledge did not make the issue of culture explicit. This has been the characteristic of the western view of mathematics concept formation (Sutherland, 1992), that culture seems to have no place in the process of concept formation (Barrett & Dickson, 2003; Bright, 2003). Concept formation therefore seems to concentrate on factors that are internal to the learner (learner's cognition, maturation and so on) with no emphasis on the culture (Inhelder & Piaget, 1958; Piaget, 1953, 1954). This approach to concept formation seems to influence the Ghanaian system very much. The details of how it has influenced mathematics curriculum development and delivery in Ghana are presented at the end of concept formation in fractions and measurement below.

2.1.3.2 Formation of concept of fraction.

Literature points to the fact that teaching and learning of the concept of fractions continues to be a major problem in mathematics education (Clarke, Roche & Mitchell, 2008; Clarke, Sukenik, Roche & Mitchell, 2006; Carke & Roche, n.d; Driscoll, 1984; Theunissen, 2005) and therefore continues to hold the attention of mathematics teachers and education researchers worldwide (Meagher, 2002). Issues concerning the knowledge of fractions, the order in which fractions are to be presented and how the concept should be presented continue to attract the attention of researchers (Hunting, 1999; Mack, 1998; Tzur, 1999). Mack (1998) for instance stresses the need to take students' prior knowledge into consideration when teaching fraction. It is against the background of the need to consider students' prior knowledge in the teaching of fractions that in this study fractions have been included in the concepts to be investigated, at the very least to add to the literature on how students' out-of-school knowledge of fractions could inform how fractions should be presented in school.

Literature points to the cultural nature of concept of fraction. According to Freudenthal (1983) for instance, the concreteness of fractions does not end with breaking a given whole into parts, but also includes comparing objects which are separated from each other or experience. This he terms "fraction as comparer" and gives examples such as "in a room there are half as many women as a men", "the bench is half of the height of the table" (p.145). Related to this theme of fraction as a comparer is the issue of fractions in everyday language such as "half as many", "half as much" which by analogy imply "equally as", "twice as …" in comparing quantities and values of magnitude (Freudenthal, 1983, pp. 134 &135).

This shows the cultural nature of the concept of fractions. It also raises a question about the universality of this concept (as most people might think). It is possible that different cultures may interpret this western view of halves in everyday language differently in different contexts. In the Ghanaian context for example, it is common for people to describe an auditorium three-fifths full of audience as half ("fã") and two-fifths full also as "fã". Thus in the Ghanaian culture half does not necessarily mean equal halves. Hence half of may not necessarily be interpreted as "equal as" or "twice as". Also the issue of fair share in fraction as fracturer in the school context may not be the same as in the home context in Ghanaian society, and the researcher supposes in many cultures as well. It is possible for a junior colleague for instance to accept less than half of a parcel shared between him/her and a senior colleague as a fair share. Thus fair share may not always imply equal share as in the classroom situation. In one context it may be interpreted as equal share and in another context it may be interpreted as what is satisfactory to those who are sharing.

A look at the mathematics curriculum for fractions in Ghana shows that this topic is introduced at grade 2 (Ministry of Education, 2001, p. 28). It begins with the concept of half and the teaching strategies emphasise the use of cultural artefacts such as a loaf of bread, orange, a piece of string. However this trend does not go beyond grade two. The curriculum then suggests the introduction of one-fourth and the teaching approach emphasise the use of paper folding (Ministry of Education, 2001, p. 29) and the approach becomes gradually more abstract as students move up the grade levels. The approach suggested in the development of the concept of fractions in this curriculum is very similar to what Freudenthal (1983) describes as "fraction as fracturer". It begins with part(s) whole relationship using concrete objects and then becomes abstract.

The use of the out-of-school knowledge acquired by students through their culture on sharing is not mentioned at all. The teaching strategy suggests the use of equal sharing of things between people. This, in the opinion of the researcher, may create conflict in the minds of children, since in the home context sharing between two people does not necessarily mean sharing into equal parts (as already noted). The facts that lessons in fractions are deliberately designed to remain silent on children's prior knowledge of sharing does not necessarily mean children will automatically unlearn what they already know. They may accept the new rules for sharing as another way of sharing which is peculiar to the school, and therefore exacerbate their view of school mathematical practices as different from home, or reject them. In the latter case these students may not pay attention to equal divisions in partitioning of a whole for instance, and the school may eventually brand such students as failing students. The question that comes to mind is why the Ghanaian primary school mathematics curriculum emphasises the use out-of-school mathematics in the formation of the concept of measurement in only grades one and two, but not in other grade levels?

2.1.3.3 Formation of concept of measurement.

Measurement is a topic that cuts across all grade levels at the primary school level in Ghana (Mireku, 2004). It is important as both a foundation for many applications of mathematics in real life and an essential element of more sophisticated mathematics (Bright & Clement, 2003). However, the observation Bishop (2002) made regarding philosophies of mathematics education which are silent about the role of culture in mathematics teaching and learning seems to influence the formation of the concept of measurement such as measuring of length for example.

Measurement in local settings in Ghana usually involves the use of local units of measures, as already noted in Section 2.1.2. The units of measure for rice for instance include “half-margarine cup”, “margarine cup”, “Olonka” and “rubber” (see Appendix A). In the Ghanaian mathematics syllabus for primary school the teaching approach suggested for teaching of measurement at grade one and two clearly shows the element of culture (as already noted in section 1.1.2). The curriculum mentions the use of arbitrary units such as foot and stick in measuring lengths, the use of milk tins in measuring capacities, comparing weight by observing (feeling the weight), and the use of events to tell the time (Ministry of Education, 2001, p.13-15; p. 30). However, this trend does not go beyond grade two. From grade two onwards the use of elements of culture cannot be seen in the development of the concept of measurement. In grade six, for example, no mention is made of the use of arbitrary units in measuring perimeter; the activity suggested included measuring the sides of the objects in metres (m), centimetres (cm) and millimetres (mm) and then adding them together in order to find the perimeter.

A lesson observation on the teaching of perimeter reported by Mereku (2004) succinctly describes the situation. In this lesson Mereku reports a grade six teacher who introduced the concept of perimeter by reviewing concepts of polygons using cut-out shapes such as square and hexagon. The teacher showed the shape and asked students to describe the properties – number of sides, square corners or right angles. The teacher then drew two rectangles on the chalk board and wrote down the formula for perimeter, $p = 2(l + w)$. Through questioning she guided students to identify lengths and widths of the rectangles and then asked them to substitute these into the formula to calculate the perimeter. The teacher worked one or two examples and asked for some volunteers to try some more on the chalkboard. The teacher then wrote five similar exercises from the mathematics textbook on the chalkboard and asked students to copy them in their notebooks and do as home work.

Examination of the lesson presented shows clearly that concept formation in measurement pays very little attention to culture. Unlike in grade one where many out-of-school contexts were used in the development of the concept of measurement, the reverse was the case in this lesson. The questions that come in mind are, why should this be the case? Can a research study help to improve the situation?

Literature that has been reviewed so far in this chapter show the cultural aspect of mathematical knowledge and mathematics curriculum. In the next section, drawing on sociocultural theory, literature on cultural aspect of mathematics pedagogy will be presented.

2.2 Socio-cultural Theories of Learning

As this research has set out to explore how children experience mathematics within the out-of-school context and in-school context and how the former influences their mathematical conceptions and practices in school, it will be important to discuss the socio-cultural view of learning. Socio-cultural views are very important in this study because, unlike other learning theories such as the constructivist theory that do not recognise the role of culture in learning, socio-cultural theories emphasise the role of culture in learning (as already noted). Vygotsky's seminal theories on learning therefore provide a way into the researcher's problem which helped to frame this study. The researcher perceives Vygotsky's work as bringing together cultural knowledge alongside conceptual concepts. In this section therefore Vygotsky's theories of learning and their application in research will be discussed.

2.2.1 Vygotsky's Theories of Learning and Their Application in Research

While both constructivist and the socio-cultural theorists seem to agree about the fact that both internal and external factors (environment) play some roles in the process of a child's learning, the former view about the role of the environment seems to be static. Piaget for instance, views knowledge construction as being attained through one's interaction with the world, thus acknowledging the role of the environment (Sutherland, 1992), but rather emphasising the innate ability of the child. Socio-culturalists on the other hand view knowledge construction beyond the innate factors of the individual learner. They view it as being socially constructed through the learners' participation in activities practiced in their cultures. Thus to the socio-culturalist social interaction plays a vital role in a child's learning (Vygotsky, 1978).

Vygotsky (1934/1987) distinguishes two kinds of concepts, the one being everyday concepts and the other scientific concepts. From Vygotsky's perspectives, an everyday concept is acquired through the child's participation in social activities within the child’s culture. Their (everyday concepts) development occurs in out-of-school settings, they are experienced based, situated and often spontaneous. Scientific concepts on the other hand are systematic. They are acquired through a system of formal instruction. Gallimore and Tharp (1990) therefore refer to these as “Schooled” concepts because they arise through the social institution of schooling. Panofsky, John-Stener & Blackwell (1990) argue that everyday and scientific concepts are interconnected and independent and that their development is mutually influential and that the one cannot live without the other. This implies that everyday concept forms the basis for the formation of scientific concepts. This view is supported by their claim that everyday concept provides the ‘living knowledge’ for the development of scientific knowledge. Everyday concept is also transformed by scientific concepts. Children’s interaction with the scientific concept in school influences their perception and use of everyday concepts in the out-of-school context (Panofsky, John-Steiner & Blackwell, 1990/Vygotsky 1934/1987). The implication of the literature reviewed so far on the socio-cultural views of children’s learning shows that children’s everyday concepts acquired through their culture plays a vital role in their *meaningful learning [the researcher’s emphasis]* in school and in their ability to apply what they have learnt to their environment.

Related to issue of everyday and scientific concepts is the issue of mediation in a child’s learning. This includes the role of mediation by humans and through the use of symbols (Kozulin, 2003). Human mediation includes the teacher helping the child to move from one stage of learning to another stage. This brings into focus what Vygotsky referred to as the Zone of Proximal Development (ZPD). According to Vygotsky the Zone of Proximal Development is the space between the child’s capacity to solve problems on his/her own (i.e. the child’s actual development), and his/her capacity to solve problems in collaboration with a more competent person (the child’s potential development). This is reflected in his assertion that “what the child is able to do in collaboration today he will be able to do tomorrow” (Vygotsky 1934/1987, p. 211). The interaction between the ‘teacher’ and the taught serves as mediation in the development of the child’s higher thinking process. Thus the core of Vygotsky (1978) theoretical framework is the fundamental role of this social interaction in the process of the child's cognitive development. That is, how interaction stimulates the internalisation of psychological functions, especially transmissions from inter mental functioning to intra mental functioning.

The implication here therefore is that whoever is collaborating with the child in his/her bid to attain the potential development should be knowledgeable in the child's everyday concepts and be able to draw on these to help the child to increase his/her knowledge. As we have clearly seen, the development of scientific concepts depends on everyday concepts.

Cultural artefacts such as language influence an individual's thought and personality features (Sutherland, 1992). According to Schǜz (2004) language is a crucial tool in the process of cognitive development in the sense that advanced modes of thoughts are transmitted to the child through the use of words. Thus, the use of such tools as language may act as mediating influences on children's learning. This is a crucial issue in the education of children, not only in developing countries such as Ghana that practices bilingual education where the language of instruction in school is very different from the language that the majority of children speak at home, but also in developed countries that host large numbers of immigrants (see Sections 2.2.2 & 2.2.3 below).

Researchers have shown that the out-of-school mathematics practiced in cultures usually lends support to pupils' learning outcomes in the study of formal mathematics in school (Draisma, 2006; Cherinda, 2002; Saxe, 1988). Saxe (1988) for instance has said that:

> supports that Japanese culture provides with respect to the value place on mathematics, the Japanese children's cultural practices relevant to mathematics (e.g. the abacus, kuku), and the linguistic regularity of Japanese numeration each constitute a factor intrinsic to language background that is a probable source of Japanese children's mathematical competence (p. 59).

Literature suggests that teachers' understanding of students' cultures, languages, and values appears to influence their effectiveness in conveying academic subject matter and its relevance to students (Pinxten & Francois, 2007; Cocking & Chipman, 1988). Pinxten and Francois (2007) give an account of how they used learners experience in their culture to help them to develop the concept of geometry. Charborneau and John-Steiner (1988) have also given an account of how a teacher could tap learners' experience within their culture to help them experience a gradual shift from informal mathematical thinking to the more formal approaches demanded by textbooks. They however, assert "the work of Gingsburg and Russell (1981) supports the theory that Children from all ethnic and language minorities enter school with good backgrounds, but schooling alters this" (p. 94). Their claim supports the results from Walkerdine's (1988) study which revealed that schools do not usually offer opportunities for children to negotiate multiple meanings of concepts in school. Walkerdine's study showed how formal schooling usually represses the multiple mathematical meanings children acquire through their everyday experiences from home. A more recent study by Fleer and William-Kennedy (2002) shows how formal school systems ignore children's rich out-of-school experiences.

A question raised by Abreu, Bishop and Presmeg (2002), " It is unclear why a person can use mathematics competently in one practice, example street mathematics and then experience tremendous difficulties in learning the mathematics associated with another practice, example school" (p. 10), succinctly describes the Ghanaian situation. It is unclear why children can use the "pon" system of money counting, for instance, to buy and sell in the out-of-school setting but struggle to memorise two times table (as already noted in Section 1.5). It is also difficult for the researcher to understand why students can go through all the difficult arithmetic to arrive at the total cost of items purchased in the sale of candies and fruits in the home context but still have difficulty with arithmetic in the school context.

Researchers are therefore calling for the necessity of bridging out-of-school mathematics with mathematics that is taught in school to enhance children's understanding of mathematics (Matang & Owens, 2004; Owens, 1999; Presmeg, 1998; Scholnick, 1988). Scholnick (1988) for instance has said that:

> it is taken for granted that mathematics learning is embedded in a cultural context. Yet there are many cultural contexts within a society so everyone does not approach adding and subtracting in the same way … it is equally important to specify the necessary bridging structures between home and school and between one concept and another that enable the child to learn mathematics. (p. 87).

Owens (1999) also argues that "where the Indigenous culture is either strong or in need of preserving, students need to learn the mathematics of the culture. These conceptual, contextual mathematics have intuitive meaning for children. They form the foundation of learning." (p. 165)

The use of semiotics in linking out-of-school and in-school mathematics has been highlighted by many researchers especially in ensuring that students make connection between their everyday practice and the mathematical concepts that are taught in classrooms (Presmeg, 2007). According to Presmeg a semiotic framework that uses chains of signification has the potential to bridge the apparent gap between out-of-school and in-school mathematics. This according to her could be done through a process of chaining of signifiers in which each sign "slides under" the subsequent signifiers. Presmeg argues further that "in this process, goals, discourse patterns, and use of terms and symbols all move towards that of classroom mathematical practices in way that has the potential to preserve essential structure and some meanings of the original activity" (p.444). In this model, the communicator of the concept plays a very important role in the selection of signifiers in any attempt to bridge the gap between out-school and in-school mathematics. This concept of semiotics resonates well with Freudenthal's (1991) definition of horizontal mathematics (Section 1.3) and Vygotsky's idea of the Zone of Proximal Development (ZPD) (Section 2.1).

In this section, literature on sociocultural support for mathematics pedagogy was discussed. In the next section two examples of sociocultual research in local context will be examined to ascertain how students make use of out-of-school mathematical knowledge in school mathematics, and how the teacher can make a difference in students' efficient use of out-of-school mathematical knowledge in school mathematics.

2.2.2 Socio-cultural Research in Local Context

Saxe (1985) found from his study on how children (grades 2, 4 and 6) use the body system to solve arithmetical problems and how context was influencing its use, that children at high-grade levels employed adequate procedures using the body parts system of counting compared to young children. Children at lower-grade level used inadequate procedures to obtain answers, since they had no means of keeping track of what they had already counted, when the sum required reuse of the same body parts. Children at higher-grade level, on the other hand, invented a means of keeping track of the body parts in computational problems. Grade 6 students in the study extended the procedure to solve arithmetic problems which exceeded the limits of their body parts system by making use of their ability to count in English and Oksapmin. Their unschooled counterparts who were included in Saxe's study used virtually only inadequate body part strategies for all varieties of computational problems.

The finding on the children from higher-grade level and the lower grade level seems to confirm the theory that maturation affects student learning (see Burns, 1992 in Section 2.1.3 above), but the finding on the unschooled children seems to add the dimension of the school factor, which enabled the grade six students to do what their peers in the unschooled group could not do. This confirms the interaction between everyday and scientific knowledge (see Panofsky, John-Steiner & Blackwell, 1990 in Section 2.2.1 above). The issue that remains unanswered is the question of the actual reason behind the success of high-grade level students in counting beyond the number of body parts. The question is, were they able to reuse the body parts during counting because of their exposure to the concept? Was it because they were more matured than the lower-grade pupils? Or both?

If it was because of maturity, then one could argue that their unschooled counterparts were equally matured. If it was because of exposure, then one could also argue that the lower grade students also had some exposure (of course probably not the same as the higher-grade level pupils). It is possible for one to argue that the out-of-school experience does not help the unschooled because counting larger numbers is not in their experience, but in the researcher's view this argument may not hold in all contexts. If one considers Zimbabwe for instance, where an unschooled child may have to use a currency note of 200,000 in daily practice (BBC News, September 2007; BBC News, May 2006), then readers will agree with the researcher that the argument of unschooled children not encountering large numbers in daily life may be erroneous. The question therefore is, do maturation and exposures to school mathematics affect the use of out-of-school mathematics?

Draisma (2006) conducted a study in Mozambique aimed at evaluating an approach to the teaching of early arithmetic in which the possibilities of the use of gestures with their 1-5-10 structure was explored, in combination with verbalisation of the gesture computation in Portuguese and in local Mozambican languages. The study employed an experimental design to investigate the impact of teaching gesture and oral computations on students' learning outcome in arithmetic (i.e. solving problems involving addition and subtraction). Lessons of four teachers who were taken through training on the use of gestures and oral computation were observed. The study found that all the teachers succeeded in having their students calculating, at the end of Grade Two, sums and differences within the limit of 100, using gestures and explaining all steps of the computations. Thus in this study the grade two students were able to reuse their fingers to solve problems which exceeded the number of fingers.

The finding from Draisma's study seems to support the assertion that culture of students could be used as asset rather than a liability in mathematics teaching and learning (Matang & Owens, 2004; Presmeg, 1998). In Draisma's study, teachers' knowledge of students' culture enabled them to help their students to use what they knew in order to do what they could not have done without the teacher. Through the use of finger counting and verbalisation (which formed part of the children's culture) these teachers were able to help these children to add beyond the number of fingers. Thus grade two students (lower grade-level) in Draisma's study could reuse their body parts (fingers) to solve problems in which the answer exceeded the limit of the body parts (fingers). In contrast, students at the same level in Saxe's study could not do that. Draisma's finding justifies the assertion of Cocking and Chipman (1988) and Charboneau and John-Steiner (1988) that teachers' knowledge of students' culture influences their learning outcomes. It is clear from these observations that teachers' knowledge of culture does strengthen cultural support for mathematics learning. Having reviewed studies on cultural support in mathematics learning, the researcher will now discuss the language of instruction and children's mathematics learning outcomes in the next section (i.e. Section 2.2.3).

2.2.3 Bilingualism and Mathematics Language

Communication plays a vital role in mathematics learning. Literature suggests that it enhances relational understanding among students (Steele, 2001). Language is a medium through which mathematical concepts are communicated to students. Thus language plays a critical role in the process of mathematics teaching and learning. Charbonneau and John-Steiner (1988) assert "language is the critical mediator of concept formation and concept development" (p.95). Spanos, Rhodes, Dale and Crandall (1988) stated that, "language skills are the vehicles through which students learn, apply, and are tested on mathematics concepts and skills" (p.222). Similarly Durkin (1991) argues that "mathematics education begins in language, it advances and stumbles in language and its outcomes are often assessed in language" (p.3). Literature suggests that language proficiency among language minority students in the United States of America is a far stronger predictor of academic performance than either cognitive style or intellectual development. Thus language proficiency seems to be a strong predictor of cognitive functioning. However, linguistic proficiency in English, although necessary, does not seem to be a sufficient condition for high academic performance (De Avilla, 1988, p.116).

Literature suggests that an opportunity for bilinguals to study in their home language until they develop adequate knowledge of language of instruction does enhance their learning outcomes in mathematics (Adler, 1998, 2001; De Avilla, 1988; Setati & Adler, 2001). De Avilla (1988) for instance asserts that:

> under classroom organisational condition where language minority students are provided with access to multiple resources including home language, peer consultation, and so on, they will acquire concepts as easily as main stream students while at the same time acquiring English language proficiency and basic skills.(p.118)

Related to this issue of the language of instruction is the issue of the language of tests. Literature suggests that it is most appropriate to assess the cognitive ability of bilinguals in their most proficient language (Davis, 1991; De Avilla, 1988; Howie, 2002; Tsang, 1988). A study by Tsang (1988) on mathematics achievement characteristics of Asian-American students using secondary data revealed that the language of a test has impact on students' achievement, especially when the test is not in the language the students is very proficient in.

Literature suggests that there is weakness in problem-solving performance when the language of instruction is students' weaker language (Mestre, 1988; Spanos, Rhodes, Dale & Crandall, 1988). Spanos, Rhodes, Dale and Crandall(1988) found in their study on linguistics features of mathematical problem solving that "students who lack certain kinds of experience or whose experience has been different from or even contradictory to the experiences presupposed by certain word problems are apt to encounter difficulties" (p.232). Mestre (1988) observed in his study on the role of language comprehension in mathematics problem solving that language deficiencies lead to misinterpretations of word problems; the resulting solutions may be incorrect yet mathematically consistent with students' interpretation of the word problem. Studies done in Ghana on mathematics achievement and the language of tests confirm the literature above (Davis & Hisashi, 2007).

The literature reviewed so far on the language of instruction and the language of tests seems to support Vygotsky's assertion of the interaction between language and cognition (Sutherland, 1992). Whilst bilingual students who study in a classroom context in which the language of instruction is not their main language struggle to understand both mathematics and the language of instruction during mathematics lessons, their teachers usually face an onerous task of teaching both mathematics and the language of instruction at the same time (Setati, Adler, Reed & Bapoo, 2002). It is against the background of the interaction between language and cognition that this study was designed to also look at how language as a cultural artefact influences students' mathematics conceptions and practices. In the next section bilingual education in Ghanaian schools will be discussed.

2.2.4 Bilingualism Situation in Ghanaian Society

Bilingual education as it pertains in Ghana seems to be historical in its origin. Literature points to the fact that local languages were used at the lower primary level from 1529 to 1951, with the first legislation on the use of a Ghanaian language promulgated in 1925. From 1951 to 1973 the use of Ghanaian language as a medium of instruction had a chequered history until 1974, when Ghana reverted to the use of the old policy of using a Ghanaian language as a medium of instruction for the lower primary level (Owu-Ewie, 2006), which has been enforced up to the present. An attempt was however made to change this policy in 2002, but this was met with resistance. It is not clear (to the researcher) what informed the bilingual education policy in Ghana, where a local language is used as a medium of instruction for the first three years. Colin (2001) reports that "Experiments in United States of America, Canada and Europe with minority language children who are allowed to use their minority language for part or much of their elementary schooling show that such children do not experience retardation in school achievement…" (p. 175).

However, it seems the implementation of bilingual education as it is currently done in Ghana may not yield the expected students' learning outcomes (especially in mathematics), since communication plays a vital role in classroom discourse. Cummins (1981) asserted that there exists a minimal level of linguistic competence (a threshold) that a student must attain in order to function effectively in cognitively demanding academic tasks. This threshold of cognitive academic language proficiency (CALP) can take between 5 and 7 years to develop in a student's second language. Cummins explains that there are Basic Interpersonal Communication Skills (BICS) which take a relatively shorter time for bilinguals to acquire (two years), but children who acquire only the BICS may fail to understand the content of school curriculum and fail to engage in higher order cognitive processes in the classroom such as analysis, synthesis and evaluation. These cognitive processes are very important in problem solving and therefore may affect the performance of students who possess only BICS in mathematics problem solving. Hakuta, Butler and Witt (2000) found that English proficiency for ordinary conversation takes three to five years to develop, while academic English take four to seven years. Shohamy (1999) found that heterogeneous immigrant students in Israel required seven to nine years in order to catch-up with native speakers in Hebrew literacy.

The literature that has been reviewed so far shows that instruction in the local language only for the first three years (grades 1 to 3) as it is done presently in Ghana may not be good enough, in the sense that at the end of grade three students may not have acquired the cognitive academic language proficiency (CALP) to be able to understand the content of the school mathematics curriculum in English. A study has been carried out in Ghana to investigate teachers' and students' views about the Ghanaian language policy, but the result (especially at the primary school level) seems to be somewhat equivocal. As this study revealed that the implementation of the planned curriculum at the macro level influenced teachers' and students' responses (i.e. school philosophy about language use influenced teachers' and students' response) (Amissah et al, 2001). The question here therefore is; are the independent voices of primary school students and teachers heard in the issues relating to bilingual education which is being implemented currently in Ghana? Or is it only at the policy level? Will another research study help to throw more light on students' and teachers' views on the language of instruction in Ghana (as students and teachers remain the final 'consumers' of the school curriculum)? Having reviewed the literature on the cultural aspects of mathematics and mathematics pedagogy, transitions between contexts of mathematical practices will be reviewed in the next section, as this study also aims to investigate how students experience mathematics between the home and the school contexts (as will be seen in the research plans in Chapter three).

2.3 Children's Transitions between Home and School

Researchers are pointing to the fact that learners bring meanings to their mathematics lessons (Abreu, Bishop & Presmeg, 2002; Fleer & Robbins, 2005), and that exploring these meanings and using them to the child's advantage in the development of their higher thinking process may result in better learning outcomes in mathematics (especially in a developing country like Ghana). However, it seems that what educators need to know in order to see this happening in classroom setting is still not known (at least in the Ghanaian context). Abreu, Bishop and Presmeg (2002) therefore suggest the need to research how individuals and/or social groups experience their participation in and transition between two or more sociocultural mathematical practice.

In this study the researcher is looking at transition as movement between contexts of practices or major cultural institutions such as between home and school. Abreu, Bishop and Presmeg (2002) have proposed four kinds of transitions process (Lateral transitions, Collateral transitions, Encompassing transitions and Mediational transitions) based on the work of Bronfenbrenner (1979) and Beach (1999). For the purpose of this study the researcher will focus on only two, namely collateral transitions and encompassing transitions, as these two best describe the transitions Ghanaian students may go through.

According to Abreu, Bishop and Presmeg (2002):

> Collateral transitions, where there are two or more related practices requiring relatively simultaneous involvement... example is the situation where the school students' parents emigrated after being at school in their home country, and the student is exposed to one set of mathematical practice and representation at home and another set at school...
>
> Encompassing transitions, where the individuals or groups experience a significant change in mathematical practices due to historical changes within their own developing institutions or communities of practice, giving rise to cognitive and social conflict... (p. 17)

In the home context it is very common for adults to describe a bucket three-quarters full of water as “insu sin” (in Fante dialect), and a bucket three-fifths full of water also as “insu sin”. "Insu" means water whiles "sin" means less than whole, thus implying that in the home context fractions are not usually differentiated. That implies that a bucket half full of water or a bucket three-quarters full of water are all described as “sin”, which means less than a whole, but the reverse is the school situation where children have to differentiate fractions and even compare them. In the home context children make use of empty tins in measuring (i.e. “cups”, “Olonka” and so on). The metric system of measurement is not usually used in the local markets either in urban or rural settings (GNA, May 2009a). Financial news on national radio stations usually quotes prices of commodities in these local units (“Olanka” for example) but unfortunately these local units have no place in the classroom mathematics curriculum.

The language of instruction in school (especially at the upper primary level) is different from the language children use at home and even outside the classroom in most cases (as already noted). The approaches students may use in the representation of a typical arithmetic problem may also differ between contexts (home/school), as Abreu (1993) observed with children of Brazilian sugar cane farm workers, where children are taught metric systems of measurement in schools whiles at home they used their local unit of measurement based on ‘braças’. These struggles between school and home contexts of mathematical practices by Ghanaian students could be described as being collateral in nature. Literature suggests that such mismatch between out-of-school and school mathematics (as prescribed in school curriculum) usually constrains teachers from using out-of-school mathematics, since they are obliged to follow the school curriculum (Abreu & Duveen, 1995).

Other studies of relevance to this research mention parental support in terms of supporting children’s mathematics learning at home and communication with children’s teachers (Abreu & Cline, 1998; Epstein & Salinas, 2004; O’toole & Abreu, 2003), as well as parental attitudes towards mathematics (e.g. Cocking & Chipman, 1988) as variables that seem to influence students’ learning outcomes. Abreu and Cline (1998) for instance found in their study in a multiethnic primary school in South East England that children’s school performance was facilitated where parents were able to support their child’s mathematics learning at home (p. 16) and were able to communicate successfully with teachers (p.19). The researcher cannot say much about the parental expectations and support in the Ghanaian situation (since there is virtually no study in this area), but through this study the researcher wishes to gain more insight into that issue. However, the researcher’s experience as a primary school teacher gives him the impression that some parents may have the intention to support their children’s mathematical learning, but the introduction of the new mathematics programme (modern mathematics) has made things difficult for them. When the researcher was a primary school teacher, two parents/guardians told him that "teacher, we wish we could help our children but we are unable to do that because we read ‘traditional’ mathematics but nowadays this generation is doing modern mathematics" One of them told the researcher how she reads her child's notes in order to understand the assignments before she could offer some help. The other said she could not help but was prepared to pay for extra tuition for the child after school. The second context describes an example of some of the encompassing transitions that some parents/guardians may be experiencing due to changes that occurred as a result of the shift from ‘traditional’ mathematics to modern mathematics. Understanding the influence of these transitions on students' mathematical conceptions and practices in school, the role that the home (parents/guardians) and the school (teachers/headteachers) could play to turn these experiences to be a positive one for the students may provide some solutions to students' poor performance in mathematics in Ghana.

There is the tendency for Ghanaian students to experience cultural conflicts as they encounter different kinds of mathematics in the home and the school contexts. Conflict of this nature in itself is not bad in the educational setting (Bishop, 2002), but the way conflicts are handled in the classroom setting is what makes the difference. Teachers usually ignore the cultural conflicts by concentrating on their acculturation process. But the possibility is that the student may adopt the new ways of doing things that may be alien to their culture (i.e. adopting the host culture in Bishop's words), or may decide not to be part of the new cultural practice (be an outsider in Bishop's words). Bishop (2002) gives accounts of how teachers make it impossible for students to engage in cultural interaction even when the student makes the initiative. Other studies support the fact that in some cases teachers' notion about the fact that out-of-school mathematics and in-school mathematics are mutually exclusive affects their teaching. Such teachers usually make no reference to out-of-school mathematics in their lessons (Abreu, 1995; Abreu & Duveen, 1995).

Bishop (2002) suggests that, rather than ignoring cultural conflicts in the classroom as a way of solving conflicts, teachers may rather create conditions for cultural interaction to take place, "which will involve an alternating and reciprocating development of conflict and consensus, resulting continuously in both consonance and dissonance" (p. 198). Despite the fact that the focus of his study was on immigrant students whose situation may be quite different from the subjects of this research, Bishop's point about the need for teachers to respect all cultures present in the classroom is very relevant to this study. The studies that have been conducted on cultural conflicts seems to focus very much on immigrant children, but not many studies have been done in the context where subjects experience different contexts in mathematical practices between school and home in their home countries like Ghana.

As the researcher already explained in the beginning of this section, Ghanaian primary school students also experience conflicts which may in one way or another affect their mathematics learning in school. This study will therefore contribute to literature in this area by looking at the kinds of cultural conflicts that students bring forward in mathematics lessons; how teachers handle those cultural conflicts; why they handle them the way they do; and how those conflicts influence students' mathematical conceptions and practices in school.

From the discussions so far one could see that teachers' role in the acculturation process of school children is very crucial. They are officially responsible for the process of inducting the future generation into the "new" mathematical culture in school, and therefore have authority to decide what children learn and how they learn at each point in time in the classroom. Related to this issue of teachers' authority is the issue of labelling. Labelling in itself is not bad, but the simplistic use of labelling in the classroom setting could be very detrimental to students' learning. Labelling may offer very little recognition of different experiences and abilities that learners bring with them into the classroom. After all, the so called "less able" students are so labelled and usually excluded from the formal school system according to the rules of the practices in which they find themselves (Bishop, 2002). The question is; are these students who are labelled as failing and therefore excluded from school system really failing students, or it is the school curriculum which is failing them? In other words, are the failing students in Ghana rightly labelled?

Bishop (2002) argues that "Productive power recognises that teachers do not need to just accept unthinkingly the institutionalised system of ideas about mathematics education ... They have the possibility to mediate the system of ideas through their own involvement with groups and individuals in their network of 'colleagues' who share the task of acculturation" (p. 203). He suggests that parents are the most powerful set of 'colleagues' with whom teachers can work together in order to help children to achieve meaningful mathematics learning. The implication here therefore is that teachers' willingness to acquire knowledge about children's out-of-school mathematical practices and the way they learn in their home context through their cooperation with parents may provide some help in the classroom. This is very important, as more researchers are also calling for the need to bridge out-of-school and in-school mathematical knowledge, and learning experiences (Fleer & Robbins, 2005; Fleer & Kennedy-Williams, 2002; Matang & Owens, 2004; Presmeg, 1998). Having looked at the research done in other countries, the researcher will now throw light on the Ghanaian situation, as Ghana remains the focus of whole study. In the next section, therefore, the literature on the participation of parents/guardians and the community in general in schools' activities in Ghana will be presented.

2.3.1 Community Participation in Education – The Ghanaian Context

Much is known about the cooperation between school and community when it comes to the issues of whole school development in Ghana (USAID/Ghana, January 2002). School Management Committees (SMC) comprising opinion leaders and Parent Teacher Associations (PTAs) contribute considerably in the total development of schools in Ghana. They contribute to the management of the school and in some communities support the provision of infrastructure, furniture and textbooks to the schools (Pryor & Ampiah, 2003a; USAID/Ghana, January 2002). The activities of these SMCs and PTAs, however, seem to vary from one community to another.

Headteachers and teachers are expected to ensure a healthy relationship between the school and the community. Headteachers play a number of roles in organising relationship (meetings for example) between the school and the home. Some of these include planning Parent Teachers Association (PTA) meetings in consultation with the chairman of the Parent Teacher Association in each academic year, inviting parents of truant children to discuss their children's behaviour, inviting people with special expertise, such as a health personnel or a fetish priest for example, to the school to either talk with students or demonstrate traditional ways of doing things. The fetish priest for instance may be invited to demonstrate how to pour a libation in a religious and a moral education lesson.

The official role of teachers in facilitating transition in Ghana is not documented, apart from their role of ensuring good relations between the school and the community. Usually the practice is that students who are not able to cope with the school curriculum are branded as weak. Teacher education programmes in Ghana at the basic school level, however, seem to prepare prospective teachers in school community relations; trainees take a course in school community relations in their final year. The course is supposed to prepare teachers on the need to locate conflict between the community and the school, cooperate with the community to solve problems and the need to draw on resources within the community (Ghana Education Service, 2004, p.210).

The impact of this course on teachers' role in helping students' in transition between contexts of mathematical practices is not clear. However, studies have shown the relationship between student achievement, parents' communication with teachers and parents' ability to assist student in transition between contexts of mathematical practices (Abreu & Cline, 1998; Abreu & Cline, 2003). Abreu and Cline (2003) for instance found in their study in a multiethnic primary school in England with a group of high achievers and low achievers that parents of high achieving children communicated regularly with their children's teachers and also supported their children's mathematics learning at home, thus helping them to go through their transition experiences smoothly. The low achievers on the other hand did not have parents who communicated with the school nor do help with their learning at home to enable them go through their transition experiences smoothly due to their parents' poor English proficiency.

Whilst it is generally known that most PTAs and SMCs contribute to the general school development in communities, relatively very little is known about teacher, parent(s) relationship in students' mathematics learning in Ghana, even though literature suggests that teacher, parent(s) relationship in students' mathematics learning enhances students' mathematics learning outcomes (Epstein & Salina, 2004). Therefore in this study it is important to investigate parents' and teachers' collaboration in assisting students' mathematics transitions between the home and school in Ghana. In the next section the research questions that will guide the study will be presented.

2.4 Research Issues and Questions

Based on the problem stated in Section 1.5 and the theories and previous research reviewed in this chapter, two general research issues will be studied. They are: (1) what are the sociocultural influences on Ghanaian students' mathematics learning? (2) What are Ghanaian children's transition experiences between the school and home contexts and how do these affect their learning in school? These issues will be studied by focusing on particular questions, as follows:

1. What are the sociocultural influences on Ghanaian students' mathematics learning?

   Three aspects of this research issue will be investigated under the following specific research questions:

a. Do Ghanaian headteachers', teachers' and students' perceptions of 'mathematics' permit the inclusion of out-of-school cultural notions within the Ghanaian school mathematics curriculum?

In Sections 2.1 and 2.2 the researcher highlighted the cultural aspects of mathematical knowledge and mathematics pedagogy, and explained the dominance of ISM in the Ghanaian primary school mathematics curriculum. Question (1 a) is posed not only to ascertain how easy/difficult an attempt to introduce sociocultural curriculum and/or sociocultural teaching (see Section 1.7) could be, but also to throw light on how headteachers' and teachers' perceptions could possibly explains students' conceptions and practices in mathematics in school. Headteachers' and teachers' perceptions about mathematics are also important for this study because their perceptions will enhance the interpretation of results from children's interviews generally, which forms the core of this study.

b. Which language(s) of instruction do Ghanaian primary school students, teachers and headteachers prefer? Why?

In Section 2.2.4 the need to ascertain the independent voice of teachers and students in the language of instruction policy in Ghana became apparent from the discussion of the literature reviewed. This question is therefore posed to elicit the independent views of students, teachers and headteachers, and compare them to see how the views of the students' reflect those of the teachers' and the headteachers'and the Ghanaian language of instruction policy. The question is also posed to help investigate how language as a sociocultural tool influences students' conceptions and practices in mathematics in school.

c. To what extent does exposure to school mathematical culture affect Ghanaian students' use of out-of-school mathematical practices in the classroom context?

In Section 2.2.2 the researcher raised a question about the effect of the exposure to school mathematics on the use of out-of-school mathematics in school. This question is thus posed to explore how the exposure to ISM affects the use of OOSM in school.

2. What are Ghanaian children's transition experiences between the school and home contexts and how do these affect their learning in school?
   Four aspects of the second research issue will be investigated under the following specific research questions:

a. What cultural differences do students bring forward in mathematics lessons? How do teachers usually handle them? Why do they handle them the way they do?

In Section 2.3 the researcher reviewed literature which highlighted both the fact that learners bring meanings to mathematics learning, and also Ghanaian students' transitions between the home and the school. This question is therefore posed to ascertain the cultural differences Ghanaian students' bring with them in mathematics lessons and how their teachers handle these, with the hope of ascertaining how this might influence their conceptions and practices in mathematics in school.

b. In what ways do Ghanaian students make use of their knowledge of out-of-school mathematical practices in the classroom context?

This question is more of a follow up to 2 (a); it is aimed to explore how Ghanaian students make use of OOSM in ISM, especially as the Ghanaian primary school mathematics curriculum reflects mainly ISM (as was seen in Section 2.1.3).

c. To what extent do Ghanaian students' preferences for language of instruction reflect their thinking language?

As the researcher explained in Section 2.3, the medium of instruction in mathematics in school is not Ghanaian primary school students' main language. Students may have to make transitions between their main language and the language of instruction in their attempt to understand mathematics lessons. This question is therefore posed to ascertain how the language in which students would prefer to study mathematics reflects the language they use in thinking, in typical mathematical activities.

d. To what extent do Ghanaian primary school teachers and parents collaborate in assisting students' mathematics transition?

The researcher highlighted the paucity of studies in Ghana on parents' and teachers' collaboration in students' mathematics transitions, despite evidence of its positive impact on students' achievement in mathematics in school, in Section 2.3. He further positioned the issue of parent teacher collaboration in students' mathematics transitions as being important for this study. This question is therefore posed to explore this important issue.

Unlike the questions raised earlier in the literature review, those posed above (in Section 2.4) do not only encapsulate the main issues that were raised in the literature review but they are also goal oriented. Thus they have been formulated to address some of the pertinent issues that the researcher wishes to explore within the limited time frame afforded by the current research study. Like some of the studies reviewed (see, for example, Draisma, 2006), this study will also employ mixed methods (see, for example, Creswell, 2003, 2005, 2009) to address the research questions. The details of the methodology will be presented in the next chapter (Chapter Three).

Chapter Three - The Research Methodology

In this chapter the methodology that will be used to explore the research issues and questions that were posed in Section 2.4 will be presented. This will be done by looking at the research approach, the research participants, the data sources and the data analysis procedures.

3.1 Research Approach

3.1.1 Research Design

As this study has multiple purposes (see Section 1.6.1) and questions (see Section 2.4), the multiple paradigms (Martens, 2010, p.296) will be used. Thus in this study the mixed methods design (Creswell 2003, 2005) will be employed to collect both quantitative and qualitative data from a cross-section of research participants to address the research issues and questions that were posed in Section 2.4. The literature suggests that “multiple paradigms drive mixed methods-mixed methods can be approached from a pragmatic or transformative paradigm” (Martens, 2010, p.296). The pragmatic paradigm was deemed appropriate for this study as the research issues/questions will inform the methodology for this research study (Creswell, 2005; Martens, 2010).

The mixed methods approach evolved as a result of the interest by researchers in triangulating different quantitative and qualitative data sources (Jick, 1979). The literature suggests that a combination of qualitative and quantitative methodologies is recommended for thorough and comprehensive treatment of various facets of issues related to topic under investigation (Creswell, 1994, Mertler & Charles, 2008). It therefore enhances a better understanding of the research issue under consideration (Creswell, 2005; Mertler & Charles, 2008) and the attainment of the research goals more quickly (Morse, 2003). It also aids expansion of understanding from one method to another and helps to converge and confirm findings from the quantitative and qualitative data sources (Creswell, 2003; Martens, 2010). It therefore provides a more complete picture of the research issue under consideration (Mertler &Charles, 2008). Despite concerns in the literature about the amount of time required in the conduct of mixed methods research study and the need for the researcher to be knowledgeable about both quantitative and qualitative methods (Creswell, 2005; Mertens, 2010), mixed methods is recommended because of its main advantage of capitalising on the individual strengths of both the quantitative and the qualitative methods (Mertler & Charles, 2008). It is especially recommended when the researcher wants to "build from one phase of research to another" (Creswell, 2005, p.510).

In this study, therefore, a sequential mixed method strategy (Creswell, 2003) will be used to collect both quantitative and qualitative data (see Figure 3.1). The first research issue and questions will be explored using both quantitative (questionnaire surveys) and qualitative methods (interviews) whilst the second research issue and questions will be explored using only qualitative methods (interviews and documentary evidence). The researcher will now turn to the plan for the main study in the next section.

3.1.2 Plan for the Main Study

As the sequential mixed methods design will be employed in this study, the researcher will go through collection and analysis of quantitative data (Phase 1), followed by collection and analysis of qualitative data (Phase 2) (see Figure 3.1 below). The two data sets will be merged at the interpretation of the results of data analysis.

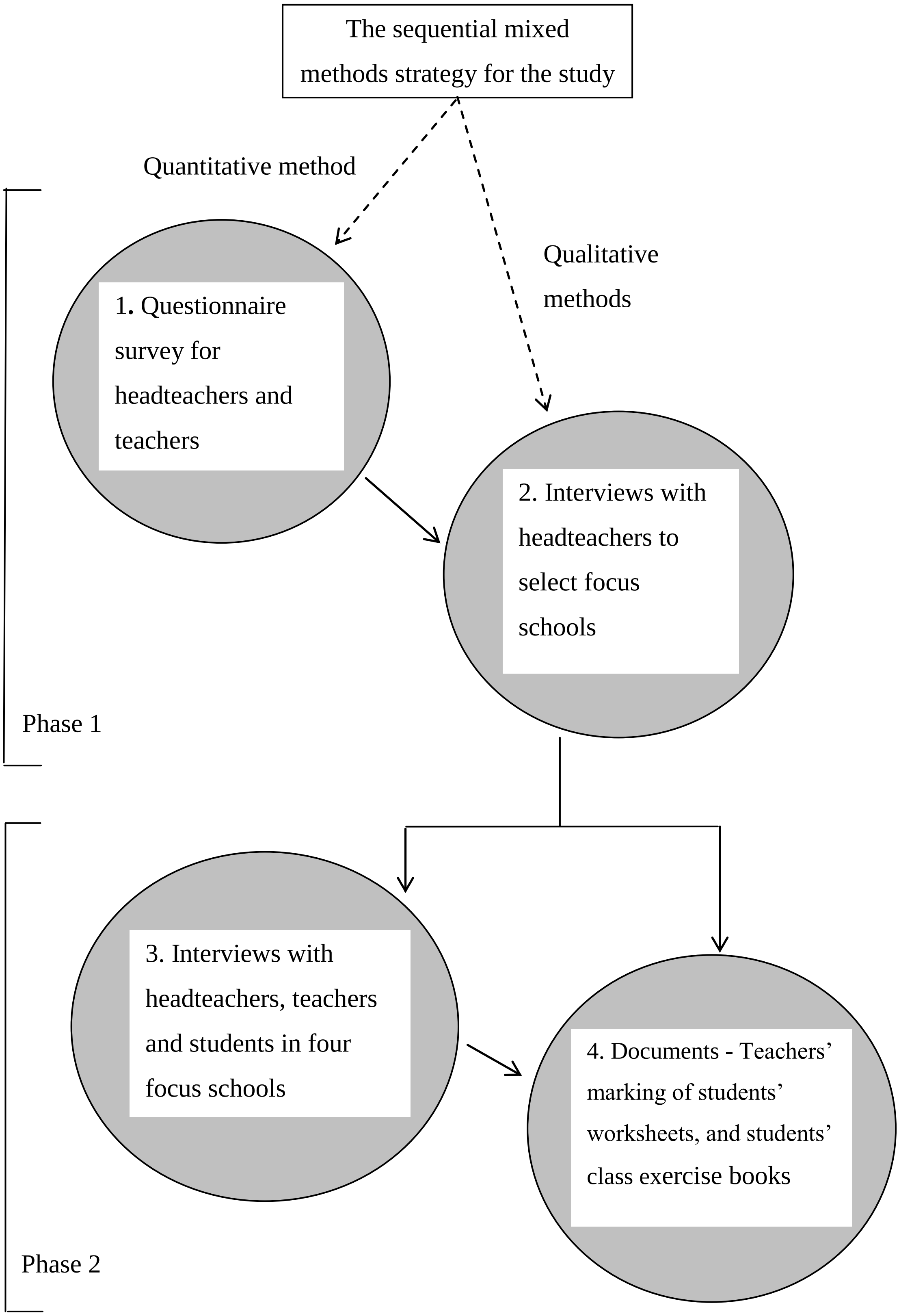


Figure 3.1. The planned sequential mixed methods for the study.

3.1.3 Data Collection

Data collection for this study will be made from three sources, as suggested in Figure 3.1 above. These are questionnaires, interviews and documents (i.e. students' class exercise books, students' worksheets and teachers' marking of students' worksheets). Further details about each on these data sources will be presented in Section 3.3. The questionnaire as a method for data collection is appropriate for this study (especially at the first stage of data collection, which involves quantitative data) because the researcher needs to generate new data from a large sample of people (Buckingham & Saunders, 2004). However, as questionnaires may be considered as not quite appropriate for young children, the perceived weakness of the questionnaire approach will be complemented by the strengths of interviews and documentary evidence from students' worksheets, teachers' marking of students' worksheets and students' exercise books.

The researcher will administer questionnaires to teachers and headteachers to collect information about their perceptions of mathematics. Information on pedagogical issues relating to cultural influences (including language) on students' conceptions and practices in fractions and measurement will be collected from headteachers, teachers and students using interviews. The researcher will focus on these two concepts (measurement and fractions) because of time limitation and reasons given in Section 2.1.3 above in justification of these two concepts.

For each of the topics, the researcher will interview grade four and grade six children. Grade six will be chosen for this study because grade six marks the end of primary school education in Ghana. This will enable the researcher to ascertain cultural influences on students' conceptions and practices in mathematics, after six years of primary education. Grade four will be chosen because grade four students would have had the experience of grappling with studying mathematics through the use of English language as a medium of instruction for a whole year. They would therefore be in the position to provide reliable information about their language preference. Also, since the study aims to investigate the influence of exposure to school mathematical culture on students' perceptions and practices (as was seen in Section 2.4) grade four will be more preferable as compared to grade five, as the closeness of grade five to grade six (one year difference) might not reveal much diversity in views, knowledge and skills. Students who will be interviewed will include high achievers and low achievers in terms of their performance in class. Teachers and headteachers will be interviewed to elicit information on parents' and teachers' influences on students' mathematics transitions. All interviews will be audio-taped. Detailed description of the interviews will be provided in Section 3.3.2.

The researcher will also collect documentary evidence from students' worksheets from the interviews, teachers' marking of students' worksheet from interviews and students' class exercise books. These documentary sources will enrich the data on cultural influences on students' mathematical conceptions and practices in school. A summary of the research issues and data collection method(s) that would be used are presented in Table 3.1 below. As shown in Table 3.1, questionnaires and interviews will be used to explore the first research issue and questions, whilst interviews and documents will be used to explore the second research issue and questions (see Section 3.1.1).

Table 3.1.Research issues/questions and research method(s) to be used in data collection.

Research Issue		Data collection method		
		Questionnaire	Interviews	Documents
1	What are the sociocultural influences on Ghanaian students' mathematics learning?	✔	✔	
2	What are Ghanaian children's transition experiences between the school and home contexts and how do these affect their learning in school?		✔	✔

In this section the data collection methods and the research questions that will be answered using each of the methods was discussed. We will now turn to consider the research participants in the next section.

3.2 The Research Participants

3.2.1 Population

This study will be carried out in the Central Region of Ghana (see Figure 4.1). The use of the Central Region in this study will give a fair representation of the Ghanaian situation. This is because demographic data in Ghana shows that less than half (45%) of the Ghanaian population live in the urban area (2003 estimate) (see NationMaster, 2003). This is also the situation in the Central Region of Ghana, as less than half (37.5%) of the population live in the urban area (2000 estimate), (Modernghana, n.d.). Also, analysis of students' performance in Basic Education Certificate Examinations (BECE) shows that this region's performance was low as compared to the other regions in Ghana (MOESS, 2007). It is against the background of low students' mathematics performance in the region as compared to the other regions in Ghana and the demographic characteristics of the Central region that the region has been chosen for the study. The population for this study will therefore consist of all primary school teachers, headteachers and school children in the Central Region of Ghana.

3.2.2 Planned Sample

The researcher will draw a sample of primary school teachers and their headteachers from the 74 public primary schools in Cape Coast Municipality for the questionnaire survey (Phase 1). Cape Coast will be selected for two reasons. Firstly Cape Coast has many schools as compared to the other districts in the Central Region of Ghana. This will therefore give the researcher a wider range of choices. Secondly doing the research in Cape Coast will also mean cutting down on cost of accommodation and transportation during seven months of data collection, as the researcher already lives in Cape Coast. The selection of schools and teachers will be based on the number of public schools. As public schools in Ghana are usually categorised by their performance, the researcher will identify all public schools in urban areas in Cape Coast Municipality of Ghana. He will then group them according to their performance (i.e above average, average and below average, as determined by Basic certificate Examination scores or Performance Monitoring Test (PMT) scores). He will also identify public schools in rural areas, and group them according to their performance. Using proportional stratified sampling procedure (e.g. Martens, 2010), the researcher will randomly select from above average, average and below average performing schools from these cluster of schools in the rural and urban areas, ensuring that all circuits (Cape Coast, Aboom, Bakaano, Ola/Apewosika/Kwaprow, Abura/Pedu and Efutu) and public school types (single sex/coeducational, mission/municipal/district council) are represented. The summary of the planned selection procedure is presented in Figure 3.2.

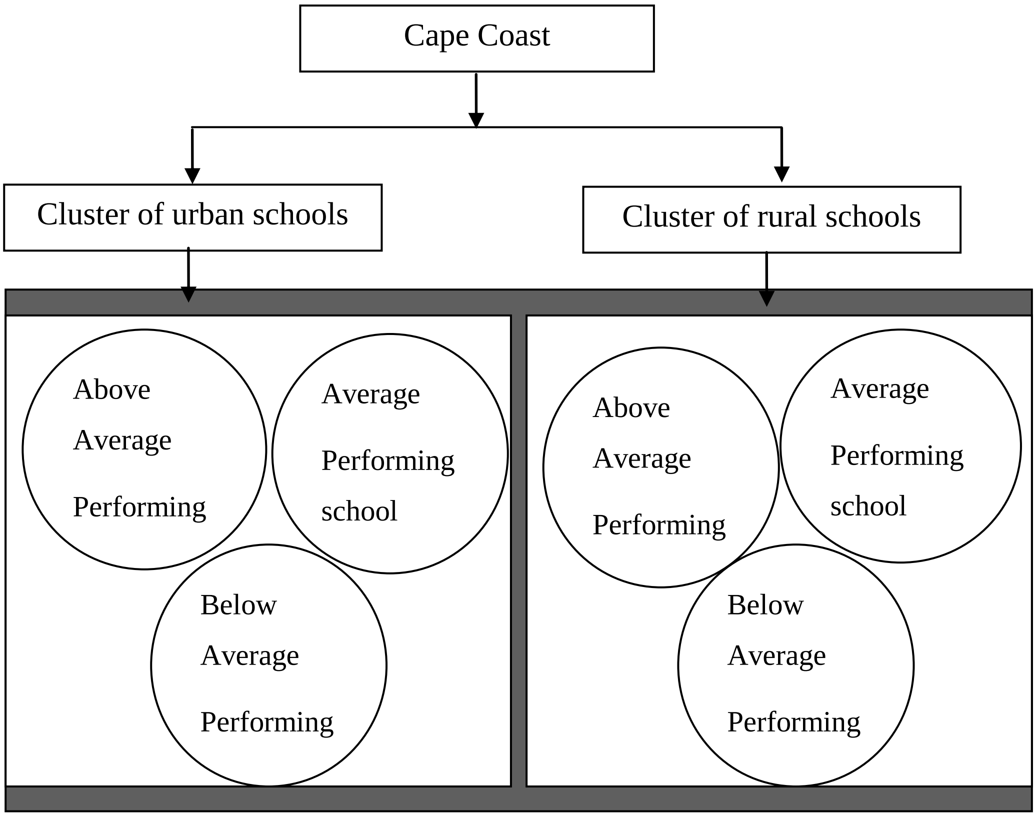


Figure 3.2. Selection of primary schools for the study.

Having discussed the research participants for the study we will now turn to the data sources.

3.3 Data Sources

The data sources for this study will be questionnaires, interviews and documents (see Section 3.1). Two research instruments have been prepared to be used in this study. These are questionnaires and interview guides. In this section details about the questionnaires and the interviews will be presented, as well as the explanation of how documents will be collected.

3.3.1 Questionnaires

The researcher has prepared two sets of questionnaires, one set to be administered to headteachers and the other set for teachers. Both sets of questionnaires consist of two main parts. The first part elicits biographical data of the respondents whereas the second part elicits information about respondents' perceptions about mathematics. The teachers' questionnaires consist of 55 items, items one through11 elicit the biographical data of the respondents, whereas items 12 through 55 elicit their perceptions about mathematics (see Appendix C).

Out of the 44 items that elicit information on teachers' perceptions about mathematics four of them are open-ended items and the remaining 40 are closed ended items. The closed ended items involve multiple choice, yes/no and Likert type items. Some of the multiple choice and yes/no items are followed by follow up questions (where necessary) (see Appendix C). This will enable the researcher to get more insights from the respondents (Fraenkel & Wallen, 2006). The majority of the items are closed ended items since it is easy to score and code them for computer analysis.

The items covered mainly four areas of perceptions, namely perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, and perceptions about links between culture and mathematics pedagogy (see Table 3.2).Very few (4) of the items were general in nature (see Appendix C, items 25, 28, 32 and 36).

Each of the four main areas of perceptions consisted of a mix of culture-related items and culture-free items. Items that had social cultural connotations were categorised as culture related items, whilst those that disregarded social cultural connections were categorised as culture-free. Thus items such as "mathematical truth is fixed" were labelled as culture-free, whereas items such as "mathematical truth can be rejected based on sound argument" were labelled as culture-related (see Appendix C, items 23 and 26). Details of the number of items in each of the four main categories are presented in Table 3.2 below.

Table 3.2. Composition of questionnaire items

	Area of perception measured	Questionnaire	Total
1	Perceptions about mathematical knowledge	Headteachers /Teachers	10
2	Perceptions about mathematics pedagogy	Headteachers/ Teachers	9
3	Perceptions about links between culture and mathematical knowledge	Headteachers/ Teachers	9
4	Perceptions about links between culture and mathematics pedagogy	Headteachers/ Teachers	12
Total			40

The questionnaire that was prepared for headteachers consist of 56 items. Items one through 12 elicit their biographical data, whereas items 13 through 56 elicit information about their perception about mathematics (see Appendix D). Minor differences existed in the formulation of the following items in the headteachers' and teachers' questionnaires Section B:

> Item 17 in teachers' questionnaire "Mathematical Knowledge is the same everywhere" and item 18 in headteachers' questionnaire "Mathematical practices is the same everywhere"

> Item 27 in teachers' questionnaire "Every Culture makes its own mathematics" and item 28 in headteachers' questionnaire "Every culture is capable of making its own mathematics"
>
> Item 44 in teachers' questionnaire "Teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson" and item 45 in headteachers' questionnaire "Teaching mathematics requires making use of what children already know."

Hence detailed comparisons of the headteachers' and teachers' results using these three items are not appropriate in this study."

The researcher constructed the items based on readings in Chapter Two and readings in the area of conceptions about mathematics (Abreu & Cline, 1998; Abreu, Bishop & Pompeu, 1997; Ernest, 1996), however a few of the items were adapted and modified from already prepared instruments (Abreu, Bishop & Pompeu, 1997, Davis, 2004). To test for the validity of the questionnaires (e.g. Mertler & Charles, 2008, p.133), the researcher pilot tested the questionnaires by giving them to fellow graduate students in education at Monash University to complete the questionnaires. The researcher used the comments received from the graduate students who responded to the questionnaire to improve the instruments. The researcher will pilot test the instruments in a pilot district in Ghana after going through ethics clearance at Monash University. Through pilot testing of instruments in Ghana, the researcher will get the opportunity to further address other problems such as clarity of question, unclear choices, difficult questions and clarity of instruction to respondents amongst others. The duration of the administration of the instruments to each of the research participants in the pilot test will also be noted. This will enable the researcher to also modify the instrument in such a way that it could be administered without taking too much of the respondents' time.

The researcher will do the administration of the questionnaires in the schools. This will enable the researcher to explain the purpose of the study to the respondents and also answer any questions that respondents may have before they complete the questionnaires.

3.3.2 Interview Guides

The researcher has prepared five sets of interview guides, two sets for headteachers, one set for teachers and two sets for students.

The researcher prepared two sets of headteachers' interview guides; one set will be administered to the headteachers to select the focus schools after the questionnaire survey (see Figure 3.1). The first set of headteachers' interview guide is made up of two parts. Part one elicits their biographical data and Part two elicits information about schools' language policy, parents' participation in schools' activity and use of OOSM in ISM (see Appendix E01).

The second set (which will be administered to headteachers of the four focus schools) is made of four parts. Part one elicits their biographical data, Part two elicits information about language use and preferred language of instruction, Part three elicits further information about use of OOSM in ISM, whilst Part four elicits information about children's mathematics transitions between the home and the school (see Appendix E02).

The Teachers' interview guide consists of four parts. Part one elicits the biographical data of the respondents, Part two elicits information about language use and preferred language of instruction, Part three elicits information about the use of out-of-school mathematics in school mathematics and Part four elicits information about children's transition between home and school contexts, and cooperation between teachers and parents in assisting children's mathematics transitions (see Appendix F).

One set of the students' interview guides will be administered at home (see Appendix G01) and the other set in school (see Appendix G02). The interview guide for interviews at home will be administered first, followed by those for interviews in school. The interview guide to be administered at home is made up of four parts. Part one elicits children's biographical data, Part two elicits information about how children experience mathematics in the out-of-school and school contexts, Part three elicits information about their perception about mathematics and Part four elicits information about language use and preferred language of instruction.

In Part two of the students' home interview guide, students are required to solve two types of mathematical problems, namely the out-of-school and in-school activities in fractions and measurement. The first type of mathematical problems (out-of-school activities) will require students to solve mathematical problems which will require them to use their knowledge of out-of-school mathematical practices in the Ghanaian culture. The second type of mathematical problems (in school activities) will require students to solve typical school type mathematical problems that are parallel to those they solved earlier in the out-of-school activities (see Part IV, Appendix G01). The implementation of the out-of-school activities, which requires the use of students' knowledge of out-of-school mathematical practices will be done in the local language, whilst the implementation of the in-school activities which will require their knowledge of school mathematics, will be done in the English language (see Table 3.3 below). This is because officially English is the language of school mathematics from grade four onwards. The local language will be used for the out-of-school activities because that is the language students use to communicate their out-of-school mathematical ideas in their everyday life.

Like the interview guide that will be administered at home (first set), the interview guide that will be administered at school (second set) also consists of four parts. Part one elicits their biographical data, Part two elicits information about how children experience mathematics in school and out-of-school contexts. Thus in part two students will be asked to solve the same problems that they solved at home. Like the implementation of the activities at home, activities that require the use of their knowledge of out-of-school mathematical practices will be done in the local language whilst the implementation of activities that will require their knowledge of school mathematics will be done in English language (see Table 3.3). Part three elicits information concerning their perceptions about the relationship between out-of-school mathematics and school mathematics. Part four elicits information about their parents' mathematical practices.

The activities in fractions and measurement will enable the researcher to explore how children use their out-of-school mathematical practices in the classroom context. It will also enable the researcher to investigate how contexts influence their conceptions and practices. The items on language use and preference, children's perception about mathematics and their parents' mathematical practices in students' interviews will also enable the researcher to get information on students' preferred language of instruction and their perception about school mathematics and out-of-school mathematics respectively. Each of the interview guides is of the semi-structured type, where the researcher will ask the interviewees predetermined questions, but at the same time allow the free flow of the interview when themes relevant to the topic come up for discussion, and also allow the interviewer to clarify uttered responses (see Appendices E, F and G).

Table 3.3. Plan of implementation of students' activities in the interviews

Context	Tasks	
	Out-of-school task	In-school task
Home	In Fante	In English
School	In Fante	In English

Note: Fante is the local language in the research locale.

As with the questionnaires, the researcher constructed the items based on readings in Chapter Two and readings in the area of conceptions about mathematics (Abreu & Cline, 1998; Abreu, Bishop & Pompeu, 1997). However a few of the items were adapted and modified from already prepared instruments (Abreu, Bishop & Pompeu, 1997). As with the questionnaires, the researcher tried out the headteachers' and teachers' interview guides in Australia with fellow graduate students in education at Monash University to ascertain whether they elicited valid responses. Through that process the feedback that was received was used to revise the instruments. The interview guides will be pilot tested in a pilot district in Ghana, after going through ethics clearance at Monash University. Data from the pilot test will be analysed to ascertain whether the questions elicit themes from respondents that address all the research issues and questions posed in Section 2.4. Also, items that are found to be ambiguous or sensitive will be revised. The duration for the administration of the instruments of each of the respondents will also be noted. This will enable the researcher to modify the instrument in such a way that it could be administered without taking too much of the interviewee's time.

The researcher alone will interview the research participants. Interviews for headteachers and teachers will take place at the school or any other place that is suitable for them, at their most convenient time. Individual interviews will be carried out with headteachers and teachers. The researcher will conduct focus group interviews with the students. The children's interviews will be done twice (as already noted in this section), once at the school and once at home. The interview at home will be done first followed by the interview at school. Also, the out-of-school task will be implemented before the in-school task (see Appendix H). This is because this study also set out to explore how students use their out-of-school mathematical knowledge in school mathematics. The researcher will negotiate with parents about the time for the interviews with students at home. Interviews with the students at home may be carried out indoors (e.g. sitting room) or at a place where there would not be any possible interference by adults/others in the community. The researcher, the class teacher and the headteacher will decide the time for the interviews at the school. In all, twenty interviews consisting of eight focus groups and twelve individual interviews will be carried out. This number (twenty) excludes the interviews with the headteachers from the original ten schools to select the four focus schools (see Figure 3.1 above).

3.3.3 Documents

The literature suggests that the use of information that already exists in some form helps in improving the internal validity of research findings, since it does not provide the opportunity for research participants to shape their responses or put out artificial behaviour (e.g. Buckingham & Saunders, 2004). In this study, therefore, the researcher will request all teachers to mark their students' worksheets on the activities that were carried out in school to ascertain evidence of how the teachers handle cultural differences that students' exhibit in the activities in fractions and measurement. This will enable the researcher to triangulate what headteachers and teachers say with how the teachers handle cultural differences from their (teachers') marking of students' worksheets. Also the researcher will collect students' class exercise books and study for evidence of the use of out-of-school cultural notions such as the use of local units of measure in lessons on measurements.

Having looked at the data sources, the researcher will now turn to the data analysis procedure that will be used.

3.4 Data Analysis Procedures

The data analysis will be done at two levels. The first level will involve analysis of what the different participants are saying and comparing responses between the different groups of participants (i.e. headteachers, teachers and school children), especially on their perceptions about mathematics. The second level will include analysis based on the four focus schools and comparing the similarities and differences in the research participants' responses across these schools.

As the study employed a mixed methods approach, both quantitative and qualitative approaches will be employed in the data analysis. The quantitative approach will involve the use of descriptive statistics (such as the means) to analyse headteachers' and teachers' perception about mathematical knowledge and mathematical pedagogy that will be collected through the use of Likert type items. In order to give more details about the distribution of responses on each of the Likert type items, a further analysis of the items will be provided through the use of frequency counts. Frequency counts (including percentages) will be used to analyse the rest of the closed ended items (yes/no and multiple choices items). Participants' responses to the open ended items on their perception about mathematical knowledge and mathematics pedagogy will be analysed by reading through respondents' responses to the various open ended items thoroughly to digest what they are saying. This will enable the researcher to have adequate understanding of the data. The researcher will then identify themes/trends that are emerging from the participants' responses and then group their responses according to the major themes that emerge, giving percentage of the respondents who gave such responses and also samples of those responses.

Data that will be generated on preferred language of instruction, children's perceptions about mathematics and children's transitions between contexts of mathematical practices through interviews will be analysed qualitatively. This will be done by organising the data according to sources (headteachers, teachers and students), transcribing the data, exploring the data to get a general sense of it, coding the data for descriptions and to form broad themes and presenting it as a narrative discussion (i.e. a written passage in which the researcher will summarise, in detail, the findings from the data analysis), (see Creswell, 2005). Students' activities that will be conducted in the local language (see Table 3.3) will be translated into English language in the interview transcript by the researcher, as the local language is the researcher's main language. Also the researcher is proficient in English, as he received all his formal education in the English language.

The documentary evidence from students' class exercise books, worksheets and teachers' marking of students' worksheet will be analysed using frequency counts with illustrative examples. This will be done by first grouping the documents according to their sources (exercise books, worksheets) and then studying the documents for evidence of the use of out-of-school mathematics logic or out-of-school mathematics representations such as the use of "Olonka" as a unit of measure of capacity, for example. These cultural influences will be discussed giving illustrative examples and the numbers involved.

In order to validate the findings of the qualitative data analysis, the researcher will triangulate the information from the various data sources (for instance, compare teachers' response on children's transitions with, headteachers' and documentary evidence from teachers' marking of students' worksheets). A summary of each of the research issues/questions and the data analysis procedure is provided in Table 3.4 below.

Table 3.4. Relationship between research issues, data sources and data analysis procedure

Research issues	Data analysis procedure		
	Questionnaires	Interviews	Document analysis
1 What are the sociocultural influences on Ghanaian students' mathematics learning?	- Descriptive statistics (means), for Likert type items - Frequency counts (percentages), for multiple choice and yes/no items - Frequency counts (percentages) and illustrative examples, for open ended items.	Qualitative analysis – reading through the data to develop a general sense of it, coding data for descriptions and to form themes, and presenting results as narrative discussion	Frequency counts and illustrative examples

Table 3.4. (continued)

Research issues	Data analysis procedure		
	Questionnaires	Interviews	Document analysis
2 What are Ghanaian children's transition experiences between the school and home contexts and how do these affect their learning in school?		Qualitative analysis – reading through the data to develop a general sense of it, coding data for descriptions and to form themes, and presenting results as narrative discussion	

In this Chapter the research design for this study, as well as the research participants, data sources and tools for data analysis, were presented. Relationships between the research issues and questions, the data sources and data analysis technique(s) were also presented. In the next Chapter the implementation of the research methodology will be presented.

Chapter Four – Implementation of the Research Methodology

In this Chapter the processes the researcher went through to implement the research methodology that was described in Chapter three will be presented. This will be done under five sub-headings namely Ethical procedures, the research locale, Pilot testing of Instruments, Results of the pilot test and the main study. With the exception of the students' activities where a few changes were made after pilot testing the instruments, the research methodology was generally implemented as was planned in Chapter three. Data collection for the research lasted for eight months starting from May 2008 to December 2008.

4.1 Ethical Procedures

In this section the ethics procedure for the entire research project and ethics procedure for the administration of the research instruments are presented.

4.1.1 Ethics Approval for Project

Before the researcher embarked on data collection in Ghana, he sought ethics approval from the Standing Committee for Ethical Research Involving Humans (SCERH) at Monash University. SCERH requested among others the need for the researcher to obtain a letter from the Cape Coast Metropolitan Director of education in Ghana, showing that the Director will receive reports concerning the conduct of the research on behalf of SCERH and also the need for the researcher to get a qualified person to translate and type parents' Consent Forms and Explanatory Statement in Ghanaian language. Ethics approval was granted for the research project to start in May 2008 once the researcher furnished SCERH with a letter from the Cape Coast Metropolitan Director of education in Ghana, type written version of parents' Consent Forms and Explanatory Statement in the local language as well as information about the background of the translator (see Appendix I).

4.1.2 Ethical Procedures in the Administration of Research Instruments

As the researcher had already sought permission from the Ghana Education Service to conduct the study (as was seen in Section 4.1.1, see Appendix J), he visited the headteachers of the schools that had volunteered to participate (after an initial invitation personally) to introduce the project to their teachers as well. The researcher introduced the project to teachers of the schools in a staff meeting during the break time and then gave them copies of the Explanatory Statement and Consent Forms. The researcher then left phone numbers with teachers for those who were interested in participating in the project to contact him.

The researcher made a short presentation to children in the classes of teachers who had volunteered to participate in the interviews after the questionnaire survey. Children who expressed interest in participating in the research project were then given children's Explanatory Statement to keep and Consent Forms to fill. Their parents' Explanatory Statement and Consent Forms were sent through them to their parents.

The researcher visited the schools later to collect the completed parents' Consent Forms (parents' responses) through the children. The researcher visited the homes of parents (three of them) who were not clear about issues concerning the Explanatory Statement and Consent Forms to explain things more clearly to them. One of the parents of a grade six student from school W (see Table 4.1) was not sure from the Explanatory Statement whether the exercise was a competition. He therefore consulted the class teacher of this student participant to find out whether the child was good enough to take part in such an activity. The researcher visited this parent to explain the whole project to him emphasising that it was not a competition and also it did not take a brilliant or weak student to take part in the activities. All that was needed were willing children and willing parents. Also, two of the parents of the student participants, one each from schools W and X were not clear about the intent of the consent form. One of them (parent of a student participant in X) visited the teacher of the child for explanation of the intent of the Consent Form. The other (from school W) came along with his child on the day the researcher planned to collect the filled in parents' consent to see the researcher for further explanation. The intent of the Consent Form was also explained to them – that it was there to protect both the researcher and the research participants. The suspicion about the intent of the Consent Forms was not peculiar to parents only but to some teachers as well (see Davis, Seah & Bishop, 2009a). This point will be addressed later in Section 8.3.2.

4.2 The Research Locale

Figure 4.1 shows the map of districts in the Central Region of Ghana. The pilot district (Komenda/Edina/Eguafo/Abriem District) where the research instruments were tried out in the pilot study and the area where the main study was carried out (Cape Coast Metropolitan Area), each have been indicated in the Figure 4.1. Komenda/Edina/Eguafo/Abriem District was chosen for the pilot testing of the instruments because the two districts are similar in terms of educational attainment at the basic school level (primary and junior high school level) (MOESS, 2007), plus they share a common culture and history. Both districts for instance share common language, served as important districts for trade during the pre-colonial era and the primary occupation in both districts is mainly fishing.

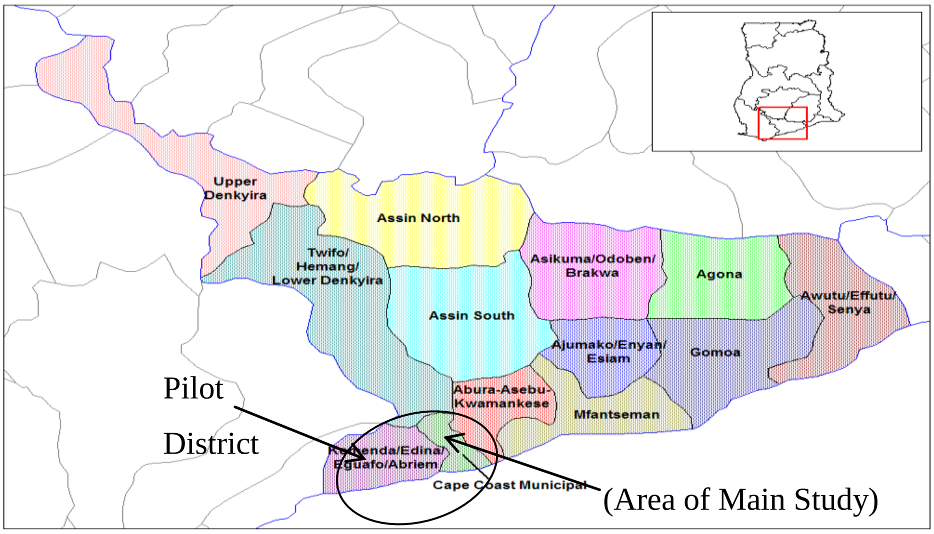


Figure 4.1. The Research locale.

Generally the socio-economic background of parents of students in the public schools in the research locale is quite low. Quite a number of people in these areas are self employed due to the limited number of industries and institutions that could offer them meaningful employment in the area. They are often either engaged in fishing, petty trading or farming. Whilst the socio economic background of the parents of these children may have implication(s) on the results for this study, the researcher does not envisage any serious implication. This is because the use OOSM is common amongst all manner of people (including the rich) in Ghanaian society (as will be seen in Chapter seven). Public school education from grade one to nine in Ghana is free and compulsory. The government of Ghana therefore mainly finances the cost of maintaining the physical infrastructure of schools, provides textbooks and also disburses money to schools every term to ensure the smooth running of schools (Capitation Grants). Quite recently (since 2006) the government of Ghana with the support of development partners has introduced a school feeding programme in poor communities. Students are given free school lunch to help reduce the financial burden on very poor parents who have difficulty catering for their children in order to keep them in school (see GNA, May 2006). Due to the huge financial burden on the government of Ghana the majority of the public schools lack facilities like electricity for example, even though electricity supply is available in most of the localities in which the schools are situated.

4.3 Pilot Testing of Instruments

Pilot testing of the research instruments began on May 2008, following the ethics approval. This was carried out in the Komenda/Edina/Eguafo/Abriem district in the Central Region of Ghana with 16 research participants comprising of four headteachers, ten primary school teachers and four primary school students (two each from grade four and six) from four schools. The researcher selected these schools randomly (using the table of random numbers) from the schools in one circuit (Edina) in the Komenda/Edina/Eguafo/Abriem district in the Central Region of Ghana. The researcher then visited the headteachers of each of these schools personally with the Explanatory Statements to introduce the project to them and to request their participation, as well as that of their respective schools. All four headteachers voluntarily agreed to participate in the pilot study. In each of the schools the researcher had a short meeting with teachers during the break time in the staff room to introduce the project to them after which he gave each of them the explanatory statement and consent form. Teachers who volunteered to participate generally declared their intention immediately after the introduction of the research project. Administration of the instruments then followed. In the next section the processes the researcher followed to pilot test the questionnaires will be presented.

4.3.1 Pilot Testing of Questionnaires

The researcher began the pilot testing of the questionnaires in each of the schools on the first day of his visit. The researcher asked the research participants to note the time they spent in filling the questionnaires. For each of the schools the research participants requested the researcher to come back for the questionnaires between two to three days time. The researcher began by administering headteachers' questionnaires followed by teachers' questionnaires in each of the schools. The researcher then visited the schools for the second time to collect the questionnaires. After collecting the questionnaires the researcher processed the data and analysed it after which he visited the schools for the third time to interview respondents about their understanding of the items in the questionnaire. This was to ascertain whether the items in the questionnaire conveyed the meaning the item was supposed to have conveyed to the research participants. Through that process items that were ambiguous as well as those that were misinterpreted were identified and improved. It took each of the research participants of the pilot study an average of 20 minutes to fill in the whole questionnaire. The details of some of the specific changes that were made in the questionnaires as a result of the conduct of the pilot test will be presented in Section 4.4.1 below.

4.3.2 Pilot Testing of Interview Guides

Pilot testing of interview guides followed the pilot testing of questionnaires in June 2008. This was carried out with a headteacher, a primary school teacher and four school children (two each from grades four and six) from one of the schools in which the questionnaire survey was carried out. Only one school was used due to delays in organising the children for the exercise. Like the teachers' and headteachers' interview guides (see Section 3.3.2), the students' interview guides were also pilot tested in Australia with a group of Ghanaian immigrant children in Melbourne to ensure that they elicited valid information before being pilot tested again in Ghana.

Interviews with both the teacher and the headteacher took place at the school premises whereas interviews with children took place in the house of one of the students in the pilot study. Both sets of students (grade four and six children) were interviewed at the same time during the pilot testing of the children's interview guide. The out-of-school tasks were implemented first followed by the in-school task in the children activities (as was planned in Section 3.3.2). However, instead of using only the local language for the out-of-school tasks and only English for in-school tasks, the researcher decided to use the language the students were most comfortable with in both the in-school and the out-of-school activities in the course of the students' interviews. This was because the researcher observed that children tended not to explain their responses when the researcher communicated in the English language especially to students who were not proficient in English. However the students named all fractions in English. The students' interviews were carried out indoors (in the lounge room of the student participant whose parent offered to allow the activities to be carried out in their home). Interviews with the headteacher took almost 20 minutes whilst those with the teachers and children took almost 28 minutes and one hour twenty minutes respectively. In the next section the results from the pilot testing will be presented.

4.4 Results of Pilot Test

Analysis of the results of the pilot test in terms of what each of the instruments was able/not able to achieve as well as what the process discussed above in the pilot test was able/not able to achieve in the pilot district will be presented. This will be done through two sub-themes namely, Questionnaires and Interviews.

4.4.1 Questionnaires

4.4.1.1 Headteachers' questionnaire.

The headteachers generally had almost no problem with the questionnaire. With the exception of only one headteacher who had difficulties with items 23 and 36, all the others were able to respond to all the questionnaire items without a problem. This headteacher misinterpreted the "values in mathematics" in headteachers' questionnaire items 23 and 36 to mean 'number'. Item 23 was therefore revised from "Mathematics is not free from values" to read "Mathematics is not free from (moral, ethical, religious etc) values" whereas item 36 was also revised from "Values are present in Mathematics teaching" to read "Values such as moral, ethical or religious are present in mathematics teaching" (see Appendix D).

4.4.1.2 Teachers' questionnaire.

Result of the pilot testing of the questionnaires revealed that even though they generally elicited the required information from the teacher participants in the pilot study, quite a few of the items were either ambiguous, unclear or difficult for the teachers to respond to. Items 22 and 35 in the teachers' questionnaires for instance appeared to be ambiguous to some of the teachers in the pilot study (two of them). These items are the same as headteachers' questionnaire items 23 and 36 (see Appendices C and D), like the headteacher (Section 4.4.1.1), the teachers also interpreted values in the item to mean 'number'. Item 47 in the teachers' questionnaire, which read "Do you believe that one's cultural practices have a place in mathematics teaching and learning in school?", appeared to be unclear to one teacher in the pilot study but when the demands of the question were explained to this teacher and the teacher understood it. When other teachers (nine of them) were requested to explain what the same item meant to them during the third visit, they were able to explain it so this item was maintained. Item 55 of teachers' questionnaire appeared to be difficult for quite a number of the teachers in the pilot study. This item is a follow up of item 54 (see Appendix C). Whilst nine out of the ten teacher participants attempted item 54, half (five out of ten) of them did not attempt item 55 at all. This was not because item 55 was unclear to them (from interaction with them) but it appeared they did not seem to have specific examples to justify their position on item 54. This item was however maintained to see what would happen in the main study which involved many teachers since headteachers and half of the teachers responded to this item without a problem. The results from the pilot testing of the interview guides will be presented in the next section.

4.4.2 Interviews

4.4.2.1 Headteachers' interview guides.

The interview questions in this instrument elicited the expected information without problems on the three main issues it was set to collect information on. These were; language use and language preference, use of out-of-school mathematics in school mathematics and finally children's transition experiences (see Appendix E). All the interview questions were answered by the headteacher without problems of ambiguity, misinterpretation or difficulty. On the language use for instance the headteacher in the pilot study expressed his opinion without fear of being victimised in any way, despite that fact that his views about the language policy differed from the existing language policy in Ghana. This may be due to the assurance of his (headteacher's) anonymity before the start of the interviews.

4.4.2.2 Teachers' interview guide.

Like the headteachers' interview guides, the teachers' interview guide also elicited the required information. Unlike the questionnaire survey, none of the interview items was either difficult or misinterpreted. The teacher also expressed her views on the issues freely without fear.

4.4.2.3 Children's interview guides.

Children's interviews began with the activities. These activities generally elicited the required responses. However, in-school activity 1(a) on identification of fraction was very difficult for students so they couldn't attempt it at all. This item required children to identify the fraction from a given set of diagrams (four of them). In each of these diagrams no divisions were shown in the whole except the shaded portion that was indicated as shown in Figure 4.2.

These items were therefore revised by bringing in the other divisions so that one-fifths from the diagram for instance was shown by dividing the whole into five and shading one out of the five as shown in Figure 4.3 (see also Appendix H02, question number 1a). Children appeared not to be familiar with the former (as shown in Figure 4.2) because a cursory look into their textbooks and some of the popular primary school mathematics textbooks in Ghana showed the use of only the latter (as in Figure 4.3) in mathematics textbooks (e.g. Wilmot & Ashworth, 2003).

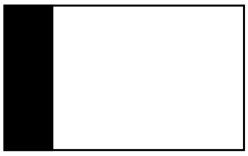


Figure 4.2. Before Pilot Testing of Instruments

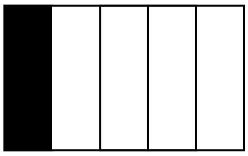


Figure 4.3. After Pilot Testing of Instruments

Also, the children had problems reading word problem. The word problem in the in-school activity 2(b) which read “Ama bought 5.5kg of rice whilst Esi bought three times the quantity of rice Ama bought. What quantity of rice did Esi buy?” for instance, was difficult for children to read and understand. The words in the question were not revised since a cursory look into their books and informal talk with grade four and six teachers in the pilot school confirmed that the words in this question were within the vocabulary of the student participants. However in implementing the main study word problems that were difficult for the children to read and understand were written in mathematical sentence form for them to solve. This was to ascertain whether English was their problem or they lacked the concept or both. Thus word problem 2(b) for instance was written as “5.5kg x 3 =” for students who could not read and understand the question.

The researcher also observed during the pilot testing of the children’s interview guides that the grade four students tended to depend on the grade six students for their solutions. This resulted in the situation where the two sets of students gave similar answers in both out-of-school and in-school tasks. In the main study therefore separate interviews was conducted to avert the recurrence of such situation where the two sets of students (grade six and four) influenced each other’s processes in solving problems particularly and their responses to other interview items generally.

As with the headteacher and the teacher in the pilot study, the students in the pilot study expressed their opinion freely on the four areas the interview guide elicited information on. These were perceptions about the relationship between out-of-school mathematics and school mathematics, children's perceptions about mathematics, perception about their parents' mathematical knowledge, and language use and preference. The researcher also observed that the children expressed themselves freely in the local language whenever the language of interview was changed to local language (Fante) but had difficulty expressing themselves (with almost all of them mostly remaining quiet) once the language of interview was changed to the English language. This situation resulted in the implementation of these parts of children's interviews in their most proficient language in the main study (which was the local language in almost all the cases).

4.5 The Main Study

In this section the procedures followed in the selection of the research participants and collection of data from the various data sources that were mentioned in Section 3.3 will be presented. Selection of the research participants for the main study will be presented next.

4.5.1 Selection of Research Participants for the Main Study

In order to maintain efficiency of the project execution against geographically-based factors, the researcher obtained the list of primary schools and their respective achievement levels from the Ghana Education Service's office. Treating the achievement levels as stratum, a sample of 150 primary school teachers and their headteachers from 25 (24 plus one spare) out of the 74 public primary schools (made up of a mix of average, above average and below average performing schools) in Cape Coast Municipality were selected for the questionnaire survey (as was planned in Section 3.2.2). Initial invitation of 25 schools was made but three schools comprising of two above average schools and one average school declined to participate later (see Davis, Seah & Bishop, 2009a). The researcher got the three replaced after a second round of invitation of ten new schools was made.

Selection of participants for Phase 2 (see Figure 3.1) of the study was done at two levels after analysis of data from questionnaire survey (as was planned in Section 3.2.2). Level one included interviews with headteachers from ten schools that gave the most “interesting responses” based on the analysis of questionnaire surveys. “Interesting responses” refers to the range of examples of mathematics practices and the variety of perceptions about mathematics (culture-related versus culture-free). Level two included choosing four primary schools based on the interviews to form sampled schools for the qualitative parts of the study. In each of these four cases, factors such as parental involvement in school, implementation of school’s language policy, and school’s perceptions about mathematics were explored. Eight teachers, four each from Grades four and six, and their headteachers were selected for interviews in the selected schools. Thirty-two primary school children, four each from the classes of each of the eight teachers from the four selected schools were also interviewed (as was planned in Section 3.2.2). In each of the schools the researcher enquired from teachers whether topics covered in students activities were topics the students were familiar with or would have treated in school before the interview dates set for the schools. All teachers responded in the affirmative.

The details of the schools selected for the various stages of the research, including their context (i.e. above average/average/below average performing, rural/urban) are summarised in Table 4.1 below. It could be seen from Table 4.1 that about seventy percent (70.1%) of the schools that volunteered to participate in the study were urban schools. This reflects the concentration of schools in the Cape Coast Metropolis where this study was carried out. School B is a big school with a double stream for each of the classes, which accounted for the large number of teachers from this school as compared to the others. School C had two teachers teaching in grade 1. School T practices subject teaching instead of class teaching from grade four so teachers who did not teach mathematics at that level declined to participate in the study. One teacher from School E and three from School J were indisposed during the period of the exercise; that accounted for their low numbers.

Table 4.1. Context of schools

School Name (Pseudonym)	School type	Location	Questionnaire Survey (T=150, H=25)	Interviews	
				Stage One	Stage Two
School A	A	Rural	× (T=6, H=1)	×	
School B	AA	Urban	× (T=11, H=1)		
School C	A	Urban	× (T=7, H=1)	×	×
School D	A	Urban	× (T=6, H=1)		
School E	A	Rural	× (T=5, H=1)		
School F	BA	Urban	× (T=6, H=1)	×	
School G	BA	Urban	× (T=6, H=1)		
School Z	AA	Urban	× (T=6, H=1)	×	
School I	AA	Urban	× (T=6, H=1)		
School J	BA	Rural	× (T=3, H=1)		
School K	A	Urban	× (T=6, H=1)		
School L	BA	Urban	× (T=6, H=1)	×	×
School M	AA	Urban	× (T=6, H=1)		
School N	A	Urban	× (T=6, H=1)		

Table 4.1. (continued)

School Name (Pseudonym)	School type	Location	Questionnaire Survey (T=150, H=25)	Interviews	
				Stage One	Stage Two
School O	BA	Urban	×(T=6, H=1)		
School P	A	Urban	×(T=6, H=1)	×	
School Q	BA	Rural	×(T=6, H=1)		
School R	AA	Urban	×(T=6, H=1)	×	
School S	A	Urban	×(T=6, H=1)		
School T	A	Urban	×(T=4, H=1)		
School U	BA	Urban	×(T=6, H=1)		
School V	AA	Rural	× (T=6, H=1)		
School W	AA	Rural	×(T=6, H=1)	×	×
School X	A	Rural	×(T=6, H=1)	×	×
School Y	A	Rural	×(T=6, H=1)	×	

Note: AA-Above Average Performing, A-Average Performing, BA-Below Average Performing
T-number of teachers, H-number of headteachers

Having discussed the selection of the research participants for the main study, the researcher will now turn to the implementation of the questionnaire survey in the next section.

4.5.2 Questionnaire Survey

The questionnaire survey began in May 2008 and ended in August 2008 in the Cape Coast Metropolitan area in the Central Region of Ghana. The researcher visited each of the 25 schools that had volunteered to participate in the study personally to administer the questionnaires. In each of the schools the purpose of the study was explained, Explanatory Statements and Consent Forms were given before the researcher showed the permission/introductory letter received from the Ghana Education Service (GES) to the respondents (as already noted in Section 4.2.2). This was to avoid the situation where the GES letter might be perceived as a tool to force research participants to participate. This was then followed by the administration of the questionnaires. Headteachers' questionnaires were administered to them at their offices whilst teachers' questionnaires were administered to them at the staff common room during break time. In each of the participating schools teacher participants and headteachers were given the opportunity to ask for clarification on items they had difficulty understanding in filling the questionnaires.

After administering the questionnaires in each of the participating schools the research participants asked the researcher to come back for the completed questionnaires between two to three days time. The researcher administered 25 head teachers' questionnaires and 150 teachers' questionnaires making a total of 175. Out of this number the researcher was able to retrieve 161 of them (constituting 92% of them). This was made up of 24 headteachers' questionnaires and 137 teachers' questionnaires. The remaining 14(8%) could not be retrieved, mainly because of misunderstanding about the intent of the Consent Forms (see Davis, Seah & Bishop, 2009a).

4.5.3 Interviews

Interviews began with the researcher's visit to headteachers from ten schools namely schools A, C, F, L, P, T, W, X, Y and Z (see Table 4.1 above). These schools were selected based on the analysis of the questionnaire survey (as already noted in Section 4.5.1). All the headteachers of the schools visited agreed to participate in the first stage of the interviews. Consent forms for the interviews were given to each of the headteachers before interviews. Each of the interviews was carried out in English, each took an average of about 18 minutes (the maximum time an interview took was 25 minutes and the minimum time was 12 minutes). Eight out of ten of the interviews were carried out at the school's premises the other two were carried out at homes of the research participants.

Based on the responses of participants (headteachers) in the interview stage one the researcher selected four schools consisting of a school that the headteacher said prohibited parents' and teachers' collaboration in students' mathematics transition (School W), a school that had the most culture related perception about relationship between culture and mathematics pedagogy (school X), a school that discouraged the use of out-of-school mathematics in school mathematics (School L) and a school which had divided perceptions on the use of out-of-school mathematics in school mathematics. Also according to the headteacher of this school, teachers use solely English as a medium of instruction from grade four onwards in the school (School C). The researcher then visited the headteachers and teachers (six of them, one each from schools X and C and two each from School L and School W) of these schools to invite them to participate in the second stage (stage two) of the interviews. In School L and School W one teacher each from grades four and six were interviewed. In School X and School C only one teacher was interviewed because these schools practice subject teaching rather than class teaching from grades four to six. Thus the same teacher teaches mathematics in grades four, five and six (i.e. upper primary).

All the headteachers and the teachers of the schools visited volunteered again to participate in the second stage of the interviews. In each of these schools the researcher gave the teachers copies of the Consent Forms for interviews to fill for the researcher. Four students, made up of a mix of average and above average students from the classes of each of these teachers were also given the children's Consent Forms and their Explanatory Statements. Parents' copies of Explanatory Statement and Consent Forms were also sent through children to their parents (as already noted in Section 4.1.2). In each of the schools the headteachers were first interviewed, followed by teachers and then students. All headteacher interviews at this stage took place at the school premises whereas the majority (five out of six) of the teachers' interviews also took place at the school premises. Only one was carried out at the teacher's home. Half of the children interviews were carried out at home and the other half in schools. Each of the children's interviews was carried out at home first followed by the interview at the school about two weeks later (as was planned in Section 3.3.2). Children's interviews began with that out-of-school activities which were implemented in the local language (Fante) followed by in-school activities which were implemented mainly in English. These activities took an average of 50 minutes in each school after which children were given a few minutes break (about 5-10 minutes break) before the researcher continued with the rest of the interviews, which was implemented in the language the children were most proficient in (but mostly Fante). During the break children were given some snack since the interviews took quite some time. Headteachers and the teachers' interviews were conducted in English language.

Each of the headteachers' interviews in stage two took an average of 25 minutes. The maximum time spent with a headteacher participant during the interview was 30 minutes and the minimum time spent was 22 minutes. Each of the teachers' interviews took an average of about 30 minutes. The maximum time spent on each of the teacher participants was about 40 minutes whilst the minimum time was about 27 minutes. This was anticipated, as the researcher asked teachers more questions than the headteachers. Each of the children's interviews took an average of one hour twenty minutes. All the interviews (headteachers, teacher and students' interviews) were audio-taped. Even though teachers from all the four schools indicated that the topics covered in the student activities were topics within the experience of their student participants (see Section 4.5.1 above), it was observed during interviews with the students that grade four student participants could not attempt in-school task 3(b) (see Appendix H02) because they had not treated that topic in school.

In all, 16 focused group interviews instead of eight (as was planned in Section 3.2.2) involving 32 student participants, 20 individual interviews involving ten headteachers (from ten schools that participated in the first stage of the interviews), four headteachers (also from the ten schools that participated in the second stage of the interviews) and six teachers from the four schools that participated in the second stage of the interviews were carried out. Samples of the interviews with the research participants are provided in Appendices K, L and M.

4.5.4 Documents

Documents collection followed after the interviews in each of the schools, however only documentary evidence from children's worksheets and teachers' marking of students' worksheets were collected for this thesis. This was because of two reasons, firstly the researcher observed a common practice of teachers using other assistants (including students in some cases) to mark students' class exercises and even tests during his visits to the schools in the course of the data collection. Secondly whilst some students generally said they used the same book for homework and class exercise, others said they occasionally did their homework in their class exercise books. However due to the limited time at the disposal of the researcher he could not find out from teachers how they moderated their assessments from class work marked by assistants neither could he get students to identify those exercises in their exercise books that constituted class work and those that constituted homework, which might have had inputs from others or which could have even been done by others but not the students themselves. It was therefore difficult for the researcher to verify the authenticity of the data source from students' class exercise books.

The collection of documents (teachers' marking of students' worksheets) was done in the last week of the school vacation in December 2008. In each of the schools the researcher requested teachers to mark students' worksheet from the students' activities that were carried out in-school for further analysis. Each of the teachers marked their students' worksheet from the students' in-school activities before the researcher and handed them to the researcher immediately after they had finished marking the activities.

In this chapter the researcher has described how the methodology that was outlined in Chapter three was implemented. Questionnaire surveys were carried out after which interviews and documents collection followed. In the next Chapter the results from the questionnaire surveys and the first of two stages of interviews (interviews stage one) that were carried out with the research participants will be presented.

Chapter Five - Results: Questionnaires and interviews stage 1

In this chapter the results of headteachers' and teachers' perceptions about mathematics will be presented. This will help to address research question 1(a), which sought to investigate whether research participants' perceptions about mathematics allow for the inclusion of out-of-school cultural notions in mathematics (OOSM) in the school mathematics curriculum (see Section 2.4). Results from the questionnaire survey will be presented under four areas of perceptions. These are perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, and perceptions about links between culture and mathematics pedagogy. Headteachers' perceptions will be presented separately from teachers' perceptions, due to their separate roles in the Ghanaian school system. In the Ghanaian society it is usual for parents/guardians to approach headteachers with any issues rather than the class teacher. Therefore the headteachers primarily have relations with the home, whereas teachers mostly deal with the students. Headteachers also serve as mediators between Government policy and the school. Presenting headteachers' and teachers' perceptions separately will therefore help the researcher to ascertain how similar or different their perceptions are. The results of interviews with headteachers of ten schools will also be presented. Based on the questionnaire survey, these ten schools were selected as representative of schools which had culture-related perceptions about links between culture and mathematics pedagogy. The chapter ends with the description of the four focus schools, selected from these ten schools.

5.1 Headteachers' Perceptions about Mathematics

In this section, the results of the headteachers' perceptions about mathematics will be presented. For the purpose of analysis of the headteachers' and teachers' responses to the Likert type items in the questionnaires, the items were rated. With the exceptions of two culture-related items, namely "mathematics should be studied by bright pupils" and "mathematics should be made an optional subject at all levels including primary school level," that were rated as follows - Strongly Disagree - 4, Disagree -3, Agree - 2 and Strongly Agree – 1, all other culture-related items were rated as follows; - Strongly Agree - 4, Agree - 3, Disagree - 2 and Strongly Disagree - 1. Culture-free items were rated as follows - Strongly Disagree - 4, Disagree - 3, Agree - 2 and Strongly Agree - 1. Thus items "mathematics should be made an optional subject at all levels including primary school level" and "mathematics should only be studied by bright pupils" as well as all culture-free (CF) items were reversal items when means were calculated. A mean score of three or higher therefore indicates culture-related perceptions, for each of the individual items in the Likert type items. The results from the Likert type items will be summarised in Tables 5.1a, 5.1b, 5.1c and 5.1e, based on the four areas of perceptions (i.e. perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge and perceptions about the links between culture and mathematics pedagogy). The results from the questionnaire items will be presented as was planned in Section 3.4.

It should be noticed that standard deviations are not appropriate to be used in the Likert type items. Also, means are mainly treated as indicative of possible information. For example in p. 111 Table 5.1a mean scores are used to report trends.

5.1.1 Perceptions about Mathematical Knowledge

Table 5.1a presents headteachers' perceptions about mathematical knowledge from the Likert type items. Results from Table 5.1a show that only 2 out of 8 of the items had mean scores of three or higher (culture-related perceptions). The remaining six items had mean scores ranging from 1.9 to 2.4 (culture-free perceptions). The results show that the majority of the headteachers held culture-free perceptions about mathematical knowledge. The majority of them either strongly agreed or agreed that, "mathematical truth is certain" (19 out of 24), "mathematical truth is unquestionable" (16 out of 24), "mathematical truth is fixed" (16 out of 24) and "mathematical knowledge is same everywhere" (14 out of 24). More than half (13 out of 24) did not agree that "mathematical truth can be rejected based on sound argument."

Table 5.1a. Headteachers' perceptions about mathematics knowledge

Item	Statements	Number of Headteachers = 24					
		NR	SA	A	D	SD	M
13	Mathematical truth is unquestionable (CF)	1	6	10	5	2	2.1
15	Mathematical knowledge is useful (CR)	-	5	19	-	-	3.8
16	Mathematical knowledge is objective knowledge (CF)	3	6	11	4	-	2.0
18	Mathematical knowledge is the same everywhere (CF)	-	5	9	7	3	2.3
19	Mathematical knowledge has many applications (CR)	-	9	15	-	-	3.6
20	Mathematical truth is certain (CF)	2	6	13	3	-	1.9
24	Mathematical truth is fixed (CF)	1	4	12	5	2	2.2
27	Mathematical truth can be rejected based on sound argument (CR)	-	2	9	9	4	2.4

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

In order to further explore headteachers' perceptions about mathematical knowledge, they were requested to indicate what comes to their mind when someone mentions mathematics to them, and what mathematics meant to them (see items 53 and 54, Appendix D). Responses on what comes to headteachers' mind when someone mention's mathematics to them are grouped into two categories, namely culture-related responses and culture-free responses. The majority (22 out of 24) of them gave culture-free responses. Half (11 out 22) of those who gave culture-free responses gave reasons relating to calculation. Some of the typical culture-free responses they gave included the following:

"Calculation" (H1, H10, H14, H23, H24),

"Study of numbers and symbols" (H3)

Only one headteacher (H11) gave a culture-related response as, "day-today-activities."

23 out of 24 headteachers responded to item 54; "Briefly explain what mathematics means to you?" Only one (H21) did not respond to it. Their responses to this item are also grouped into two categories, namely culture-related responses and culture-free responses. The majority (18 out of 23) of them gave culture-free responses. Some of the typical culture-free responses they gave included the following:

> "The ability to count, measure, add, subtract, divide numbers" (H12)
>
> "Involves symbols, algebra, numbers and shapes, in describing a concept" (H14)
>
> "Application of addition, subtraction, multiplication and division, and also algorithms in solving problems" (H18)
>
> The minority (5 out 23) of them gave culture-related response. Some of the culture-related responses they gave included the following:
>
> "It is the reaction of human mind to his/her environment, in terms of weight, time, space and so on" (H24)
>
> "Means taking measurement, playing, designing, counting and playing with object symbols" (H15)

It is evident from the results presented on headteachers' perceptions about mathematical knowledge that their perceptions were more culture-free than culture-related. They appeared to perceive mathematical knowledge as universal knowledge, which is the same everywhere in the world.

5.1.2 Perceptions about Mathematical Pedagogy

Table 5.1b presents headteachers' perceptions about mathematics pedagogy. Results from Table 5.1b show that four out of the nine items had mean scores of three or higher (culture-related perceptions), two out of nine had mean scores that ranged from 2.5 to 2.9 (trend towards culture-related perceptions), and the remaining three had mean scores that ranged from 1.9 to 2.4 (culture-free perceptions). The results reveal further that they appreciated students' involvement in mathematics lesson, as all of them either strongly agreed or agreed to the statement that, "teaching mathematics involves active participation of pupils throughout the lesson" (24 out of 24). The majority of the headteachers, however, appeared to link success in mathematics learning to the innate ability of the learner, as the majority of them either strongly agreed or agreed that, "success in mathematics depends on intellectual ability" (14 out of 24), "learning mathematics basically requires memorising facts" (14 out of 24), also about half (13 out of 24) of them either strongly agreed or agreed that, "learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise."

Table 5.1b. Headteachers' perceptions about mathematics pedagogy

Item	Statements	Number of headteachers = 24					
		NR	SA	A	D	SD	M
25	Language has nothing to do with mathematical thinking (CF)	-	4	3	8	9	2.9
32	Children are very likely to understand mathematics better when they are taught in the language they understand best (CR)	1	19	2	2	-	3.4
34	Mathematics should be made an optional subject at all levels including primary school level (CR)	-	3	-	6	15	3.4
38	Success in mathematics depends on intellectual ability (CF)	-	5	9	9	1	2.3
41	Learning mathematics basically requires memorising facts (CF)	-	6	8	7	3	2.3
42	Mathematics learning is all about practicing a given task over and over again (CF)	1	9	9	4	1	1.9
43	Teaching mathematics involves active participation of pupils throughout the lesson (CR)	-	15	9	-	-	3.6
44	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise (CF)	1	2	11	8	2	2.4
46	Mathematics should only be studied by bright pupils (CR)	-	1	-	7	16	3.6

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

It is evident from the results in Table 5.1b that headteachers' perceptions about mathematics pedagogy cannot be said to be culture-related, as a substantial minority (3 out of 9) of the items received culture-free responses.

5.1.3 Perceptions about Links between Ghanaian Culture and Mathematical Knowledge

Table 5.1c presents headteachers' perceptions about the links between culture and mathematical knowledge. Results from Table 5.1c show that only one out of the six items had a mean score of three (culture-related perceptions), four had mean scores ranging from 2.6 to 2.9 (trend towards culture-related perceptions), with only one having mean score of 2.3 (culture-free perceptions). The results show that half (12 out of 24) of the headteachers confirmed their universal view of mathematical knowledge (presented in Section 5.1.1 above), as they either strongly disagreed or disagreed that, "mathematical practices differ from culture to culture." Also a large minority of them (9 out of 24) also either strongly disagreed or disagreed that every culture makes it own mathematics. The majority of them, however, seemed to appreciate links between culture and mathematical knowledge, as they either strongly disagreed or disagreed that, "mathematics has very little relevance to indigenous communities" (19 out of 24), and "indigenous culture practices has no place in mathematics" (18 out of 24).

Table 5.1c: Headteachers' perceptions about links between culture and mathematical knowledge

Item	Statements	Number of headteachers = 24					
		NR	SA	A	D	SD	M
21	Indigenous culture practices has no place in mathematics (CF)	-	3	3	12	6	2.9
22	Mathematics has very little relevance to indigenous communities (CF)	-	1	4	14	5	3.0
23	Mathematics is not free from (moral, ethical, religious etc) values (CR)	1	4	10	6	3	2.6
28	Every culture is capable of making its own mathematics (CR)	-	4	11	6	3	2.7
35	Mathematical practices differ from culture to culture (CR)	-	-	12	8	4	2.3
36	Values such as moral, ethical or religious are present in mathematics teaching (CR)	1	4	14	3	2	2.9

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

Headteachers were further requested to indicate whether they believed the activities carried out in various societies generate mathematics, which may not be the same as school mathematics (see Appendix D, item 50). Analysis of headteachers' responses to this item revealed that the majority (22 out of 24) of them answered, "yes" to this item. Only a few (2out of 24) answered, “no” to this item because, “teaching of mathematics has nothing to do with culture (H19)” [and] “our daily activities do involve some calculations.” (H3) This implies H3’s notion of calculation is limited to in-school calculation. The result of item 50 confirms the earlier observation that the majority of the headteachers appreciated links between culture and mathematical knowledge.

Table 5.1d presents activities that headteachers believed generate mathematics (item 51). The results in Table 5.1d show that the majority of these headteachers perceived counting (83.3%), measurement (79.2%), and playing (62.5%) as activities that generate mathematics. A few of them perceived explaining (37.7%) and other activities (8.4%), apart from those presented in Table 5.1d, such as cooking, gardening, weighing items, checking inventories and writing bills, as activities that generate mathematics. This is not surprising because in the Ghanaian context explaining is embedded in all activities (see Section 2.1.2).

Table 5.1d. Headteachers’ perceptions about activities that generate mathematics

Topic	Number of headteachers=24	
	Frequency	Percentage (%)
Counting	20	83.3
Measurement	19	79.2
Locating	11	45.8
Playing	15	62.5
Designing	13	54.2
Explaining	9	37.5
Others	2	8.4

It is evident from the results of headteachers' perceptions about links between culture and mathematical knowledge that there are trends toward culture-related perceptions about the link between the Ghanaian culture and mathematical knowledge.

5.1.4 Perceptions about Links between the Ghanaian Culture and Mathematics Pedagogy

Table 5.1e presents headteachers' perceptions about links between the Ghanaian culture and mathematics pedagogy from Likert type items. Results from Table 5.1e show that the majority (6 out of 8) of the items had mean scores of three or higher (culture-related perceptions), the remaining two had mean scores of 2.5 and 2.7 respectively (trend towards culture-related perceptions). The results show that headteachers generally appreciated the support that out-of-school culture notions could offer to mathematics pedagogy, as the majority of them either strongly agreed or agreed that, "teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson" (24 out of 24), "mathematical practices in our indigenous culture can support children's learning in school mathematics" (23 out of 24), "use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively" (23 out of 24), "use of out-of-school mathematics practices in school mathematics will facilitate children's understanding of school mathematics" (22 out 24), "teaching mathematics requires using children's mathematical practices in their culture to help them to understand the lesson" (20 out of 24) and "teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning" (22 out of 24).

Table 5.1e. Headteachers' perceptions about links between culture and mathematics pedagogy

Item	Statements	Number of headteachers = 24					
		NR	SA	A	D	SD	M
14	Doing mathematics requires using rules which has little to do with indigenous culture (CF)	1	4	7	9	3	2.5
17	Mathematical practices in our indigenous culture can support children's learning in school mathematics (CR)	-	9	14	1	-	3.3
30	Nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible (CF)	-	3	5	12	4	2.7
31	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning (CR)	-	9	13	1	1	3.3
39	Use of out-of-school mathematics practices in school mathematics will facilitate children's understanding of school mathematics (CR)	1	11	11	1	-	3.4

Table 5.1e. (continued)

Item	Statements	Number of headteachers = 24					
		NR	SA	A	D	SD	M
40	Use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively (CR)	-	10	13	1	-	3.4
45	Teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson (CR)	-	14	10	-	-	3.4
47	Teaching mathematics requires using children's mathematical practices in their culture to help them to understand the lesson (CR)	-	7	13	3	1	3.0

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

In order to further explore headteachers' perceptions about links between culture and mathematics pedagogy, they were asked to indicate by ticking "yes" or "no", whether they believed that one's cultural practices have a place in mathematics teaching and learning in school. They were also requested to indicate which topics allowed for the inclusion of out-of-school mathematics (see items 48 and 49, Appendix D).The results revealed that 22 out of 24 (representing 91.7%) of them answered "yes", only two (8.3%) answered "no' to question 48 "Do you believe that one's cultural practices have a place in mathematics teaching and learning in school?"

Table 5.1f presents the topics that headteachers perceived as allowing for the inclusion of out-of-school mathematical practices (item 50). The results in Table 5.1f show that Measurement comes first, with 21 of them (87.5%) indicating that it allowed for inclusion of out-of-school mathematical practices. This was followed by fractions, with 19 of them (79.2%) and then both lines and space, and Data handling, with each of the two topics having 16 (66.7%) of the headteachers indicating that they allowed for the inclusion of out-of-school mathematical practices.

Operation on numbers was the least chosen topic, with only eight respondents (33.3%) choosing it. This was followed by game of chance, with ten of them (41.7%). This shows that more than half of the headteachers did not perceive these two topics (operation on numbers and game of chance) as allowing for the inclusion of out-of-school mathematical practices. Thus two-thirds (66.7%) of them did not perceive operations on numbers as allowing for the inclusion of out-of-school mathematical practices, whilst 58.3% did not perceive game of chance as also allowing for the inclusion of out-of-school mathematical practices.

Table 5.1f. Headteachers' perceptions about topics that allows for inclusion of out-of-school mathematical practices

Topic	Number of headteachers = 24	
	Frequency	Percentage (%)
Measurement	21	87.5
Lines and space	16	66.7
Fractions	19	79.2
Data handling	16	66.7
Game of chance	10	41.7
Operation on numbers	8	33.3
Word problem solving	12	50.2

Festivals have been the traditional mode for the preservations of the rich Ghanaian culture. In this study headteachers were asked to indicate whether they believed mathematics education could also be used as an avenue for the preservation of the Ghanaian culture (see Appendix D, item 55). Analysis of the results showed that the majority (21 out of 24; 87.5%) of the headteachers answered "yes" to this item. Only a few either responded in the negative (2[8.3%]) or decided not to respond to the item (1[4.2%]).

The reasons given by headteachers (19 out of 21 of them) who responded to the item are presented below (two headteachers did not give any reason for their answers). The reasons given by those who believed mathematics education could be a vehicle for the preservation of the Ghanaian culture are categorised into seven reasons. These are; preserving indigenous mathematical ideas in the Ghanaian culture, creating awareness about the existence of aspects of the Ghanaian culture, learning mathematics through the use of traditional games and dances, improving perception/attitudes about mathematics and Ghanaian culture, links between mathematics and the Ghanaian culture, usefulness of mathematics and unclear response.

Two out of nineteen headteachers gave reason relating to preserving indigenous mathematical ideas in the Ghanaian culture. The reasons they gave included the following:

> "The various shapes in our culture can be maintained, counting in our culture" (H1)
>
> "The use of indigenous shapes and other objects in the teaching and learning of mathematics" (H16)

Two out of nineteen headteachers also gave reasons relating to creating awareness about the existence of aspects of the Ghanaian culture as follows:

"It will enable us to know how certain aspect of our culture has been in existence" (H3)

"Festivals involves dates and mathematics can help in calculating those days on which it will be celebrated or was first celebrated" (H14)

Three out of nineteen headteachers gave reasons relating to learning mathematics through the use of traditional games and dances. Some of the typical reasons they gave included:

"Through games like Ampe and Oware people learn to calculate" (H6)

"Games like Tomato can help in learning mathematics" (H25)

Two headteachers gave reasons relating to improving perceptions/attitudes about mathematics and Ghanaian culture as follows:

"Mathematics education will improve our perception on our culture and help us to preserve our rich culture" (H10)

"As people are made to understand that the subject is not difficult through massive education, people's attitudes will change" (H8)

Eight out of nineteen headteachers gave reasons relating to links between mathematics and the Ghanaian culture. Some of the typical reasons given included:

"Everything done under the sun involves mathematics and culture is not an exception" (H12)

"Mathematics is in our daily activities and for that reason it needs to be enriched in our culture so that people may have more interest in it, especially in schools" (H17)

One out of the nineteen gave a response relating to the usefulness of mathematics as, "it helps spacing and drawing symbols" (H23), whilst the same number gave an unclear response as, “formula relating to mathematics should be preserved for other people to study and develop new ideas or improve them.” (H13)

It is evident from their reasons presented above that more than one-third (about 42%) of the headteachers who gave reasons why mathematics education could be used as a vehicle for the preservation of the rich Ghanaian culture, attributed it to links between mathematics and culture. Only a few of them attributed their reasons to others, such as usefulness of mathematics.

The two headteachers who responded “no” to item 55, attributed their reasons to mathematics and culture as being two different activities altogether. Each of them said:

> “Mathematics education has nothing to do with our culture,” (H21)
>
> “National festival of Art is different from mathematics.” (H20)

It can be deduced from the analysis of the results presented on headteachers’ perceptions about links between culture and mathematics pedagogy that this was generally culture-related. This is an indication that they perceived culture to play some role in mathematics pedagogy, despite their universal view about mathematical knowledge (as was highlighted in Section 5.1.1).

Having looked at the headteachers’ perceptions about mathematical knowledge, mathematics pedagogy, links between culture and mathematical knowledge, and links between culture and mathematics pedagogy, the researcher will now turn to the results of teachers’ perceptions about mathematics.

5.2 Teachers' Perceptions about Mathematics

As with the headteachers' questionnaire, a mean score of three or higher indicates culture-related perceptions, for each of the individual items in the Likert type items (see Section 5.1). The results of teachers' perceptions will also be presented based on the four main areas of perceptions in this study (see Section 5.1).

5.2.1 Perceptions about Mathematical Knowledge

Table 5.2a presents the teachers' perceptions about mathematical knowledge, from the Likert type items. Results from the analysis of teachers perceptions about mathematical knowledge show that only two (2 out of 8) of the items had mean scores of three or higher (culture-related perceptions). The remaining six had mean scores ranging from 1.7 to 2.3 (culture-free perceptions). The majority (135 out of 137) of the teachers acknowledged the usefulness of mathematics (item 15), however, as with the headteachers, the majority of the teachers held culture-free perceptions about mathematical knowledge. The majority of them also either strongly agreed or agreed that, "mathematical truth is certain" (119 out of 137), "mathematical knowledge is the same everywhere" (113 out of 137), "mathematical truth is fixed" (96 out of 137) and "mathematical truth is unquestionable" (93 out of 137). Almost half (72 out of 137) of these teachers, either strongly disagreed or disagreed that "mathematical truth can be rejected based on sound argument."

Table 5.2a. Teachers' perceptions about mathematical knowledge

item	Statements	Number of Teachers=137					
		NR	SA	A	D	SD	M
13	Mathematical truth is unquestionable (CF)	11	33	60	29	4	2.0
15	Mathematical knowledge is useful (CR)	2	112	23	-	-	3.8
16	Mathematical knowledge is objective knowledge (CF)	9	41	75	11	1	1.8
18	Mathematical knowledge is the same everywhere (CF)	4	67	46	17	3	1.7
19	Mathematical knowledge has many applications (CR)	2	84	50	-	1	3.6
20	Mathematical truth is certain (CF)	7	43	76	11	-	1.8
24	Mathematical truth is fixed (CF)	10	39	57	27	4	2.0
27	Mathematical truth can be rejected based on sound argument(CR)	9	8	48	48	24	2.3

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

As with the headteachers, teachers were also requested to indicate what comes to their mind when someone mentions mathematics to them and what mathematics meant to them (see items 53 and 54, Appendix C). Analysis of the results revealed that 131 out of 137 of them responded to item 53, "what comes into your mind when someone mentions mathematics to you?" Only six (T11, T23, T35, T51, T124 and T133) did not respond to it. Teachers' responses to this item are grouped into two categories namely, culture-related response and culture-free response. The majority (121 out of 137) of them gave culture-free responses. Of those who gave culture-free responses, quite a number (52 out of 121) of them gave responses relating to calculation. Some of the typical culture-free responses they gave included the following:

> "Calculation" (28 teachers),
>
> "It is a branch of science concerned with numbers, quantity and space" (T73)
>
> "Addition, subtraction, multiplication and division" (T6, T58, T74, T99, T106, T122, T129)

Ten teachers (T1, T9, T18, T19, T20, T28, T60, T59, T64 and T95) gave culture-related responses. Some of the typical culture-related responses they gave included the following:

> "Subject taught at school yet part of our daily lives" (T20)
>
> "Mathematics involves all the activities we do in our daily life" (T1)

Analysis of teachers' responses to item 55, "Briefly explain what mathematics means to you?", revealed that 126 out of 137 of them responded to this item. Eleven of them (T11, T14, T23, T51, T65, T62, T69, T87, T93, T107 and T116) did not respond to it. Teachers' responses to what mathematics meant to them are also grouped into two groups, namely culture-related responses and culture-free responses. The majority (103 out of 126) of them gave culture-free responses. Some of the typical culture-free responses given included the following:

> "Mathematics is all about calculations" (T38), (28 of them gave calculation-related responses)
>
> "The study of abstract science of numbers, quantity and space" (T58)
>
> "Adding, subtracting, multiplying and dividing" (T6, T78, T79, T105, T106)

The minority (23 out of 126) of them gave culture-related responses. Some of the culture-related responses given included the following:

> "The study of the aspect of life, be it counted measured and so on" (T5)
>
> "Mathematics is our everyday life, and it involves many things we do every day; measuring of things, playing, counting etc, are all mathematics" (T18)
>
> "Solving a problem in a meaningful situation" (T28)

The results presented so far confirms teachers' culture-free perceptions from the Likert type items in Table 5.2a. It is evident from the results presented on teachers' perceptions about mathematical knowledge that their perceptions were more culture-free than culture-related. As with the headteachers, the majority of the teachers also perceived mathematical knowledge as universal knowledge that is being perceived as the same everywhere in the world.

5.2.2 Perceptions about Mathematics Pedagogy

Table 5.2b presents teachers' perceptions about mathematics pedagogy. Results from the 5.2b show that about half (5 out of 9) of the items had mean scores of three or higher (culture-related perceptions). The remaining four had mean scores ranging from 1.7 to 2.4 (culture-free perceptions). The results show that like the headteachers, the majority of teachers appeared to also appreciate the role of the learner in mathematics pedagogy, as the majority of them either strongly agreed or agreed that "teaching mathematics involves active participation of pupils throughout the lesson" (135 out of 137). However, they seemed to perceive success in mathematics learning to be dependent on the innate ability of the learner, as the majority of them either strongly agreed or agreed to the statements, "mathematics learning is all about practicing a given task over and over again" (114 out of 137), "success in mathematics depends on intellectual ability" (96 out of 137), "learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise" (87 out of 137). The result further reveals that about half (69 out of 137) of them either strongly agreed or agreed that "learning mathematics basically requires memorising facts."

Table 5.2b. Teachers' perceptions about mathematics pedagogy

Item	Statements	Number of teachers=137					
		NR	SA	A	D	SD	M
24	Language has nothing to do with mathematical thinking (CF)	9	15	12	54	47	3.0
31	Children are very likely to understand mathematics better when they are taught in the language they understand best (CR)	2	93	35	6	1	3.6
33	Mathematics should be made an optional subject at all levels including primary school level (CR)	2	7	7	32	89	3.5
37	Success in mathematics depends on intellectual ability (CF)	4	25	71	28	9	2.2
40	Learning mathematics basically requires memorising facts (CF)	5	19	50	48	15	2.4
41	Mathematics learning is all about practicing a given task over and over again (CF)	1	69	45	16	6	1.7

Table 5.2b. (continued)

Item	Statements	Number of teachers=137					
		NR	SA	A	D	SD	M
42	Teaching mathematics involves active participation of pupils throughout the lesson (CR)	2	102	33	-	-	3.8
43	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise (CF)	5	24	63	39	6	2.2
45	Mathematics should only be studied by bright pupils (CR)	2	1	4	41	89	3.6

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

It is evident from the results presented on teachers' perceptions about mathematics pedagogy in Table 5.2b that, like their perceptions about mathematical knowledge, their perception about mathematics pedagogy was not culture-related, as a big minority (4 out of 9) of the teachers' questionnaire items had culture-free responses.

5.2.3 Perceptions about Links between the Ghanaian Culture and Mathematical Knowledge

Table 5.2c presents teachers' perceptions about links between culture and mathematical knowledge from the Likert type items. Results from Table 5.2c show that one-third (2 out of 6) of the items had means scores of three or higher (culture-related perceptions), two had mean scores of 2.7 and 2.8 respectively (trend towards culture-related perceptions). The remaining two had mean score of 2.3 each (culture-free perceptions). The results show that more than half of teachers confirmed their universal views about mathematical knowledge, as they either strongly disagreed or disagreed to the statements, “every culture makes its own mathematics” (72out of 137), and “mathematical practices differ from culture to culture” (80 out of 137). However, the majority of them rather seemed to appreciate links between culture and mathematical knowledge, as they either strongly disagreed or disagreed that, “indigenous culture practices has no place in mathematics” (111 out of 137), “mathematics has very little relevance to indigenous communities” (100 out of 137).

Table 5.2c. Teachers’ perceptions about links between culture and mathematical knowledge

Item	Statements	Number of teachers = 137					
		NR	SA	A	D	SD	M
20	Indigenous culture practices has no place in mathematics (CF)	6	6	14	65	46	3.2
21	Mathematics has very little relevance to indigenous communities (CF)	5	4	28	63	37	3.0
22	Mathematics is not free from (moral, ethical, religious etc) values (CR)	12	15	65	38	12	2.7
27	Every culture is capable of making its own mathematics (CR)	7	11	47	47	25	2.3
34	Mathematical practices differ from culture to culture (CR)	3	10	44	55	25	2.3
35	Values such as moral, ethical or religious are present in mathematics teaching (CR)	8	18	80	23	8	2.8

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

As with the headteachers, teachers were also requested to indicate whether they believed the activities carried out in various societies generate mathematics, which may not be the same as school mathematics (see Appendix C, item 49). The results from the analysis of their responses show that 126 out of 137 (92%) of them answered "yes" to this item, 10 (7.3%) answered "no", with only one (0.7%) declining to respond. This shows that the majority of them believed that activities teachers and students carry out in their societies could generate some form of mathematics. This confirms the finding from the Likert type items in Table 5.2c above that the teachers appeared to appreciate some links between culture and mathematical knowledge.

Table 5.2d presents teachers' choice of activities that they thought could generate mathematics (item 50). The results in Table 5.2d show that as with the headteachers, the majority of these teachers perceived counting (84.6%) and measurement (74.5%) as activities that generate mathematics. About two-fifths of them (40.9%) perceived explaining as an activity that generates mathematics. Very few (2.2%) perceived other activities apart from those presented in Table 5.2d, such as cooking, eating, walking, games and identifying as other examples of activities that generate mathematics.

Table 5.2d. Teachers' perceptions about activities that may generate mathematics

Topic	Number of teachers = 137	
	Frequency	Percentage (%)
Counting	115	84.6
Measurement	102	74.5
Locating	72	52.6
Playing	70	51.1

Table 2d. (continued)

Topic	Number of teachers = 137	
	Frequency	Percentage (%)
Designing	59	43.1
Explaining	55	40.4
Others	3	2.2

One out of the ten teachers who did not believe that activities carried out in various societies generate mathematics, which may not be the same as school mathematics did not give reason(s) for saying "no" (T107). Of the nine (T22, T26, T49, T51, T64, T70, T82, T95, T119) who gave reasons for saying "no", the majority (7 out of 9) of them rather gave culture-related responses. Thus their argument appeared to negate rather than supporting their stance on universal nature of mathematical knowledge. Some of the typical culture-related reasons they gave included:

> "All activities carried in our society generate mathematics just that it is not put on paper but comes through thinking" (T119)
>
> "In our various societies we use numbers to count, container and others things to measure. In terms of location we use turn left, right, go straight we also use numbers to play and explain various things" (T95)

In their attempt to justify their perception about the universal nature of mathematical knowledge, by looking at some of the mathematical practices in the society, these teachers failed to consider how the different cultures (classroom and home cultures) approach mathematics. In her attempt to justify her universal view about mathematical knowledge, T64 rather justified the point the researcher has just made about teachers' failure to recognise approaches from the different cultures; "they all take the same procedure, just that the approach differs."(T64) Thus in T64's views in adding, for instance, things are put together in both the home and the school contexts, but how things are put together often differs between the two contexts.

Only two (T22 and T51) gave culture free-responses as, “because mathematics is the same everywhere, there is no difference in home mathematics and school mathematics,” (T22) and “Mathematics is the same everywhere.” (T51)

It is evident from the results presented on teachers’ perceptions about links between culture and mathematical knowledge that such links are rather appreciated by the teacher participants. Thus the results generally showed trends toward culture-related perceptions about the links between culture and mathematical knowledge.

5.2.4 Perceptions about Links between Culture and Mathematics Pedagogy

Table 5.2e presents teachers’ perceptions about links between culture and mathematics pedagogy. Results from Table 5.2e show that the majority (6 out of 8) of the items had mean scores of three or higher (culture-related perceptions), whereas the remaining two had mean scores of 2.5 and 2.7 respectively (trend towards culture-related perceptions). As with the headteachers, none of the teachers’ questionnaire items on the links between culture and mathematics pedagogy had a culture-free response. The results show that like the headteachers, the teachers also appreciated cultural support for mathematics pedagogy, as the majority of them either strongly agreed or agreed that “mathematical practices in our indigenous culture can support children’s learning in school mathematics” (132 out of 137), “use of out-of-school mathematics practices in school mathematics will facilitate children’s understanding of school mathematics” (128 out 137), “use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively” (126 out of 137), “teachers’ knowledge of mathematical practices in learners’ culture may help in mathematics teaching and learning” (122 out of 137), “Teaching mathematics requires using children’s mathematical practices in their culture to help them to understand the lesson” (121 out of 137), and “Teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson” (132 out of 137).

Table 5.2e. Teachers' perceptions about links between culture and mathematics pedagogy

Item	Statements	Number of teachers=137					
		NR	SA	A	D	SD	M
13	Doing mathematics requires using rules which has little to do with indigenous culture (CF)	11	14	53	41	18	2.5
16	Mathematical practices in our indigenous culture can support children's learning in school mathematics (CR)	1	67	65	4	-	3.5
29	Nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible (CF)	6	8	41	64	18	2.7
30	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning (CR)	4	41	81	8	3	3.2

Table 5.2e. (continued)

Item	Statements	Number of teachers=137					
		NR	SA	A	D	SD	M
38	Use of out-of-school mathematics practices in school mathematics will facilitate children's understanding of school mathematics (CR)	3	42	86	5	1	3.3
39	Use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively (CR)	3	30	96	8	-	3.2
44	Teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson (CR)	2	93	39	2	1	3.7
46	Teaching mathematics requires using children's mathematical practices in their culture to help them to understand the lesson (CR)	2	30	91	12	2	3.1

Note: NR-Number of non-responses, SA-Strongly Agree, A-Agree, D-Disagree, SD-strongly Disagree

In order to further explore teachers’ perceptions about links between culture and mathematics pedagogy, they were asked to indicate whether they believe that one’s cultural practices have a place in mathematics pedagogy (see Appendix C, item 47). Results from analysis of teachers’ responses show that 115 out of the 137 (representing 83.9%) of the teachers answered “yes” to this question, 21 (15.3%) answered “no”. Only one (0.7%) of them did not respond to the item. This is an indication that the majority of the teachers also generally perceived that one’s cultural practices have a place in mathematics pedagogy. This confirms the results in Table 5.2e, which revealed culture-related perceptions about links between culture and mathematics pedagogy.

Table 5.2f presents the topics that teachers perceived as allowing for the inclusion of out-of-school mathematical practices (item 48). The results in Table 5.2f show that Measurement came first, with 102 of them (representing 75% of all the 137 teachers) indicating that it allowed for the inclusion of out-of-school mathematical practices, followed by fractions, with 87 of them (63.5%), followed by data handling, with 74 of them (54.0%). Other topics such as addition and subtraction (which is also part of operation on numbers) was the least chosen by three of them (2.2%), followed by operation on numbers, which was chosen by 46 of them (33.6%). This is an indication that about two-thirds (66.4) of the teachers also did not think operation on numbers allowed for the inclusion of out-of-school mathematical practices.

Table 5.2f. Teachers' perceptions about topics that allow for inclusion of out-of-school mathematical practices

Topic	Number of Teachers = 137	
	Frequency	Percentage (%)
Measurement	102	75.0
Lines and space	57	41.6
Fractions	87	63.5
Data handling	74	54.0
Game of chance	69	50.4
Operation on numbers	46	33.6
Word problem solving	69	50.4
Others	4	2.9

As with the headteachers, teachers were also asked to indicate whether they believed mathematics education could also be used as a vehicle for the preservation of the Ghanaian culture (see Appendix C, item 54). Analysis of teachers' responses show that the majority (111 out of 137; 81.0%) of the teachers answered "yes" to this item. Only a few either responded in the negative, or decided not to respond to the item (15[10.9%] and 11[8.0%] respectively).

Out of 126 teachers who answered the question, 17 of them (comprising of 16 teachers who answered "yes" to the item, and one teacher who answered "no" to the item) did not give reasons for their choice of answers to the item. This implies that 109 of them provided reasons why they either believed or did not believe that mathematics could also be a vehicle for the preservation of the Ghanaian culture. The reasons given by those who believed mathematics education could also be a vehicle for the preservation of the rich Ghanaian culture is grouped into seven categories. These are preserving indigenous mathematical ideas in the Ghanaian culture, creating awareness about the existence of aspects of Ghanaian culture, learning mathematics through the use of traditional games, links between mathematics and the Ghanaian culture, usefulness of mathematics, improving perceptions/attitudes about mathematics and Ghanaian culture, and unclear responses.

Eleven teachers gave responses relating to preserving indigenous mathematical ideas. Some of the typical responses they gave included:

> "Most of our cultural elements involve shapes, so when we are teaching shapes we can bring these elements to teach." (T38)
>
> "The proper use of numbers, shapes, can help generations to undertake all activities with ease and this will help us to understand our culture better and facilitate the preservation of the good part of our culture." (T49)

Five teachers gave responses relating to creating awareness about the existence of aspects of Ghanaian culture. Some of the typical responses they gave included:

> "The gods of Cape Coast are seventy-seven, so when teaching numerals, you can let the child know the number of gods. When this is done, at least the child's mind will click and will understand the number seventy-seven." (T70)
>
> "Mathematical symbols are seen in designs. Example is the stool." (T32)

Nine teachers gave reasons relating to learning mathematics through the use of traditional games and dances. Some of the typical reasons given included:

> "Games like draft need a lot of calculation and thinking, so through culture pupils will develops ways of calculating and thinking." (T82)
>
> "The playing of a game called 'Oware' preserves our culture as well as enhancing the learning of counting in mathematics. With this I think it helps culture and help learn mathematics." (T14)

Two teachers gave reasons relating to improving perceptions/attitudes about mathematics and Ghanaian culture. The reasons they gave were:

> "Doing that will help all to accept, appreciate mathematics as part of our daily life." (T20)
>
> "More people will know more about the importance of mathematics." (T29)

Twenty seven teachers gave reasons relating to links between mathematics and the Ghanaian culture. Some of the typical reasons given included:

> "Mathematics deals with symbols in the same way like culture, so mathematics can be a vehicle for the preservation of our rich culture." (T53)
>
> "Mathematical concepts are generated from our daily activities or the culture." (T80)
>
> "Everything that we do involve mathematics and culture too involves mathematics, hence when mathematics education is taken seriously culture as well would be preserved." (T64)

Thirty teachers gave reasons relating to the usefulness of mathematics. Some of the typical reasons that were given included:

> "Mathematics helps in our everyday life." (T130)
>
> "It will help us to explore our environment and exploit our resources for studying certain aspect of our culture." (T100)

Fourteen teachers gave reasons which appeared to be unclear to the researcher. Some of the typical reasons given included:

> "Because culture is dynamic" (T60)
>
> "To compare the percentages annually" (T117)

It is evident from the reasons given above that reasons relating to the utilitarian value of mathematics and perceived links between mathematics and culture were the major reasons why the majority (57 out of 96) of the teachers believed mathematics education could also be a vehicle for the preservation of the Ghanaian culture. Only a few (2) of them gave reasons relating to improving perceptions/attitudes about mathematics and the Ghanaian culture.

As with the headteachers, teachers (15of them) who did not believe mathematics education could be used as a vehicle for the preservation of the Ghanaian culture gave reasons relating to perceived lack/absence of link between mathematics and culture. Some of the typical responses from teachers included the following:

> "Because teaching and learning of mathematics has no association with culture." (T136)
>
> "Mathematics is not embedded in our culture." (T96)

It is evident from the results presented in this section that as with the headteachers, the teachers generally had culture-related perceptions about links between culture and mathematics pedagogy. This is an indication that they appeared to acknowledge that culture could support mathematics pedagogy.

Having gone through the results of headteachers' and teachers' perception about mathematics, the researcher will now turn to the summary of the results of headteachers' and teachers' perception about mathematics.

5.3 Summary of Headteachers’ and Teachers’ Perceptions about Mathematics

A summary of the results of each of the four areas of perceptions that were investigated are presented as follows:

Headteachers’ and teachers’ perceptions about mathematical knowledge showed they had culture-free perceptions about mathematics. The majority (8 out of 10) of the items (including open ended items) received culture-free responses. More than half of the headteachers (14 out of 24) and the teachers (113 out of 137) held the universal view about mathematical knowledge, that is, regarding it as a knowledge that is the same everywhere.

The findings from the headteachers’ and teachers’ perceptions about mathematical pedagogy showed that their perceptions were more culture-free than culture-related. A substantial minority of the headteachers and teachers items received culture free-responses (3 out of 9 and 4 out of 9 respectively). Also, more than half of the headteachers (14 out of 24) and teachers (96 out of 137) perceived success in mathematics as being dependent on innate ability of learners.

Headteachers’ and teachers’ perceptions about links between culture and mathematical knowledge showed trends toward culture-related perceptions. A third (3 out of 9 items) of the items in the headteachers’ questionnaires received culture-related responses, 4 out of 9 of the items received responses that indicated trends toward culture-related responses. Only two items in the headteachers’ questionnaires received culture-free responses. Almost half (5 out of 9) of the items in the teachers’ questionnaires received culture-related responses, two items showed trends toward culture-related response. The remaining two items in the teachers’ questionnaires received culture-free responses. The majority of the headteachers and teachers (22 out of 24 headteachers; 126 out of 137 teachers) indicated that the activities carried out in societies generate mathematics, which may not be the same as the school mathematics.

Culture-related perceptions about links between culture and mathematics pedagogy were also observed in the results of links between culture and mathematics pedagogy. The majority (10 out of 12; in each case) of the items in the headteachers' and teachers' questionnaires received culture-related responses, with the remaining two items receiving responses that showed trends toward culture-related responses. The majority of the headteachers and teachers (20 out of 24 headteachers; 121 out of 137 teachers) either strongly agreed or agreed that teaching mathematics required using children's mathematical practices in their culture to help them understand the lesson.

Having presented the summary of the results in sections 5.1 and 5.2, the researcher will now turn to the results of ten schools that gave "interesting" responses, which in this study refers to variety of perceptions about mathematics, range of examples of mathematical practices, from the questionnaire survey (see Section 3.2.2). Interview with the headteachers of these ten schools will also be presented.

5.4 Results from the Ten Schools

Results of the ten schools will be presented in this section, mainly for the purpose of selection of four focus schools (see Section 4.5.1). The results from the ten schools will be presented in two parts. The first is the summary of perceptions about links between culture and mathematics pedagogy of research participants from the ten schools. The second is the summary of interviews with headteachers from these schools. For the purpose of analysis of results by schools, the overall mean scores will be used to investigate schools' perceptions about links between culture and mathematics pedagogy. This will help to identify schools that were more open to the use of OOSM in ISM and those that were less open to the use of OOSM in ISM. A mean score of 24 (3 times 8 items) out of 32 or higher, indicates culture-related perceptions about links between culture and mathematics pedagogy.

5.4.1 Summary of Results of Perceptions about Links between Culture and Mathematics Pedagogy

An overview of analysis of results by the twenty-five schools revealed that the mean scores ranged between a minimum of 22.4(out of 32), (scored by School U) to a maximum of 28.3(out of 32), (scored by School X). The majority (15 out of 25) of the schools had mean score of 24.0 out of 32.0 or higher.

Ten schools, consisting of seven (Schools X, A, W, R, P, Z, Y) that had more culture-related perceptions about links between culture and mathematics pedagogy, and three schools (Schools L, F, C) that had less culture-related perceptions about links between culture and mathematics pedagogy were chosen. These schools were chosen for the purpose of interviewing the headteachers, in order to select four focus schools (see Table 5.3). Equal numbers of schools belonging to schools with these two varieties of perceptions were not chosen, because the majority (two-thirds) of the schools had more culture-related perceptions.

A summary of results from each of the ten selected schools are presented in order of mean scores in Table 5.3. The results in Table 5.3 show that "interesting" aspects of three schools (X, Z, Y) were based on headteachers' characteristics, that of three schools (W, R, P) were based on teachers' characteristics and the remaining four schools (A, L, F, C) were based on school's (both headteacher and teachers) characteristics.

Table 5.3. Overall mean scores of perceptions about links between culture and mathematics pedagogy by ten schools and their interesting aspects

School	N= 66	Mean out of 32	Interesting aspects
X	7(1)	28.3	Headteacher believed mathematics is, “the reaction of human mind to his/her environment.”
A	6(1)	27.3	School doesn’t believe playing is an example of mathematical practices.
W	6(1)	25.7	All but one teacher believed all six universal activities proposed by Bishop (1988) generate mathematics. This teacher believed five out of the six universal activities generate mathematics.
R	7(1)	25.0	All but one teacher did not believe playing and explaining generate mathematics.
P	7(1)	24.4	A third of teachers in this school perceived mathematics as a school subject, “mathematics is one of the subjects studied in school,” (T89) “It is one of the core subjects in the curriculum.” (T88)
Z	7(1)	24.4	Headteacher believed mathematics is, “the cashier’s subject, maths deals with formula”
Y	6(1)	24.3	Headteacher believed mathematics is, “difficult and confusing.”
L	6(1)	23.8	Half of teachers and headteacher did not believe locating and designing are examples of activities that generate mathematics.

Table 5.3. (continued)

School	N= 66	Mean out of 32	Interesting aspects
F	6(1)	23.2	Whole school believed at least five out of six of universal activities proposed by Bishop (1988) generate mathematics.
C	8(1)	22.8	School was divided on use of OOSM in ISM. Headteacher did not believe activities carried out in societies generate mathematics which may not be same as ISM.

Note: Number includes both teachers and their headteachers (one from each school)

5.4.2 Summary of Results from Interviews with Headteachers of Ten Schools

Interviews with headteachers of the ten schools covered four main areas. These were implementation of school's language policy, parental participation in school activities, use of out-of-school cultural notion by teachers in school mathematics, and headteachers' perceptions about use of out-of-school cultural notions in mathematics, such as "Olonka" in the Ghanaian society. Summary of the results of interviews are presented in Tables 5.4, 5.5, 5.6 and 5.7 below.

Table 5.4 presents a summary of the interview results on schools' language policy. The results in Table 5.4 show that headteachers of all ten schools said their schools use both the local language and English language at the lower primary level (grades 1-3). However, from grade four, the majority (6 out 10) of them said they mix the local language with the English language, whilst a substantial minority (4 out of 10) said they use solely the English language as a medium of instruction.

Table 5.4. Summary of interview results on school language policy

Features of school	N	Which school headteachers?	Quotes from some headteachers
1. School's language policy			
1.1 In lower primary			
Mixture of English and Fante (local language)	10	HA, HC, HF, HL, HP, HT, HW, HX, HY, HZ	"For P1-P3 we mix … we realize that if we go strictly by the policy sometimes they get problems when they get to the upper primary, where they have to change over to use English throughout" (HP) "In the lower primary we use both Fante and English" (HA)
1.2 In upper primary			
1.2.1 Mainly English language, however accepts the use of local language as an additional resource	6	HX, HA, HW, HF, HT, HL	" From the upper primary level it is strictly English, except when there are concepts that students do not understand" (HA) "Sometimes during teaching, some of them would not understand the lesson in English, so when you go for Fante they pick it very fast." (HT)
1.2.2 Solely English (prohibits local language use)	4	HC, HZ, HP, HY	"In the upper primary up to JHS, it is solely English." (HC) "At the upper primary, we use English throughout except the Ghanaian language class." (HP)

Table 5.5 presents a summary of results of interviews on parents' participation in school activities. The result from Table 5.5 show that the majority (8 out of 10) of the headteachers indicated that parents' participation in their school's activities mainly involves school visits, either on open days (5 out of 10) or for other reasons, such a delinquent behaviour of children (3 out of 10), and PTA meetings (5 out of 10).

Table 5.5. Summary of interview results on parents' participation in school activities

Features of school	N	Which school headteacher(s)?	Quotes from some headteachers
2. Parents' participation in school activities			
2.1 PTA meetings	5	HP, HT, HL, HY, HC	"Yes, we call them for PTA meetings" (HP) "They do come to PTA meetings regularly" (HY)
2.2 School Visits			
2.2.1 for open days	5	HX, HC, HZ, HF, HL	
2.2.3 because of delinquent behaviour of child or learning difficulties	3	HP, HT, HZ	"When there is a problem [and] we think parents should come in, we invite them in…"(HP)

Table 5.5. (continued)

Features of school	N	Which school headteacher(s)?	Quotes from some headteachers
2.3 Demonstration in lessons by parents (yes)			
2.3.1 lessons on culture	3	HW, HP, HX	"Well during some topics, we invite them … I mean things concerning culture and history, we bring them in" (HW)
2.3.2 Personal hygiene	1	HL	"We use them, there was [sic] this assemblyman [community leader] …we [usually] ask him to come and give a talk on their personal hygiene."
2.3.3 Vocational skills	1	HF	"There was a time a carpenter was invited to the school as a resource person."
2.3.4 Lesson not specified	1	HC	"they are usually invited to the classroom as resource persons but not too often."
2.4 Demonstration in lessons by parents (No)	4	HY, HZ, HA, HT	"No, the work here is just farming, that is the highest job…We look at the syllabus and we do what the syllabus wants." (HY) "No, no not at all." (HZ)

Table 5.6 presents summary of results on the use of OOSM in ISM. The results in Table 5.6 show that all but one headteacher (HL) said their school accepts the use of out-of- school cultural notions in mathematics.

Table 5.6. Summary of results on the use/non use of out of school cultural notions in mathematics in school

Features of school	N	Which school headteacher(s)?	Quotes from some headteachers
3. Use/non use of out of school cultural notions in mathematics in school			
3.1 School accepts and use	7	HX, HA, HZ, HP, HF, HT, HY	"During mathematics lesson we use tins, some use margarine tins, and so on and so forth in measuring things" (HX) "That is what they know from home, …for all levels it helps in promoting better understanding" (HP)
3.2 School accepts use at the lower primary but the headteacher has not taken notice of its use at the upper primary level	1	HW	"I have not paid attention to that, I am actually not sure …but at the lower primary level I know they are actually emphasising on those things. I do not think they [upper primary teachers] would do away with it …"
3.3 School accepts, however, some teachers use whilst others do not use	1	HC	"Most teachers have been using that, the few who don't use it perhaps they don't have much interest in mathematics…"
3.4 School discourages its use	1	HL	"Well, we don't want to encourage it, in the sense that sometimes even when the children go to the upper primary [and] because they are used to that … they feel they should continue from that level too." "I feel for home it is better."

Table 5.7 presents a summary of results on headteachers' perceptions about the use of OOSM in the Ghanaian society. The results in Table 5.7 show that more than half (6 out of 10) of the headteachers perceived out-of-school cultural notions in mathematics such as "Olonka" as being important for mathematics pedagogy. Only one of them (HL) perceived it as being important for illiterates.

Table 5.7. Summary of results on perceptions about OOSM in Ghanaian society

Features of school	N	Which school(s)?	Quotes from some headteachers
4. Perceptions about out-of-school cultural notions in mathematics			
4.1 Important for mathematics pedagogy	5	HA, HC, HX, HZ, HY	"I want to say that out-of-school mathematics is a previous knowledge that the school is building on." (HA) "It is good for children … they can do better." (HX)
4.2 Important only as a resource for mathematics pedagogy but not for inclusion in school curriculum	1	HT	"Not necessarily bringing them to the classroom, just to make them understand the topic in general."
4.3 Not fair	1	HP	The local system of measurement is not uniform, for instance, I will use my "Olonka" and somebody else will use her's, you will see that the measurement by the two of us will not be the same

Table 5.7. (continued)

Features of school	N	Which school(s)?	Quotes from some headteachers
4.4 Important for illiterates	1	HL	…, taking our mothers who have not been to school before, this is what is helping them in the market, … they cannot read, they cannot write, so without out-of-school mathematics they can't even sell; so we see that out-of-school mathematics is good for illiterates ...
4.5 Important for all	2	HF, HW	"I feel it is something we cannot do away with, we are Africans and we still use them, … civilization has brought a lot of improvements, but they are things we cannot do away with." (HF)

The description of four focus schools that are purposely selected to exemplify the different aspects of features from the results of interviews with headteachers from the ten schools will be presented in the next section. These schools represent schools with strong and articulate views about these features (see Tables 5.4, 5.5, 5.6 and 5.7).

5.5 Selection of Four Focus Schools

The four focus schools are, the school that had the most open perception on the use of OOSM in ISM (School X), a school that prohibits the use of OOSM in ISM (School L), a school that appeared to prohibit school and community collaboration in mathematics education (according to the headteacher), (School W), and finally a school that uses English language only as a medium of instruction from Grade four, and also had teachers divided over the use of OOSM in ISM (School C).

Schools X and L represented the different views of schools that encourage the use of OOSM in ISM and those that discourage its use in ISM. School C was chosen to represent the situation where both set of views operated within the same school and also represents those schools that prohibit the use of local language from grade four. School W was chosen to represent the situation of parents' participation in topics relating to traditional culture or customs in school, but not mathematics.

School W was an above average performing school. Schools X and C were average performing schools, whilst School L was below average performing school (detailed description of the four focus schools will be provided in the next section). It is evident from the composition of the four focus schools that, even though these schools were purposely chosen, they were chosen to cover as much as possible, all the features of schools in Tables 5.4, 5.5, 5.6 and 5.7, as well as all the school types discussed in Section 4.5.1.

5.5.1 Background information about the Focus Schools

5.5.1.1. About School C

School C is an average achieving school located at about 4km West of Cape Coast city. The predominant occupation in the community where the school is located is petty trading. The school has six classes from grades one to six, with student population of about three hundred and fifty. The teaching staff consisted of seven teachers, two for grade one (because of the large number of students in this grade), and one each for grades two and three. The school practices class teaching from grades one to three, and subject teaching from grade four onwards.

According to the headteacher of this school (HC), the school accepts the use of OOSM in ISM; “oh I think they are very useful, for instance, the “pole” [local unit of measuring area of farm land], is what they know from everyday life.” However, some teachers in the school refuse to use OOSM, “most teachers have been using that, the few who don’t use it, perhaps they don’t have much interest in mathematics.” Thus, the school appeared to be divided over the use of OOSM in ISM; this was also evident in the questionnaire surveys (see Table 5.3).

5.5.1.2. About School L

School L is a below average achieving school located at about 8km north of Cape Coast city. Petty trading is the predominant occupation in the area. The school has six classes from grades one to six, with student population of about four hundred. The school practices class teaching at all levels in the primary school. Interviews with the headteacher showed that this school discourages the use of OOSM in ISM (see Table 5.3), it also had the least culture-related perception about the links between culture and mathematics pedagogy (see Table 5.6).

According to HL the school has a dynamic PTA that is very supportive of the school and also monitors activities of teachers:

> we have the PTA, they have been participating, when we invite them to come to the school they come…, when there is any project in the school and we need their support they come to the school to help voluntarily. ..., we have about four of them who almost every week come to the school to see how the teachers are doing. They even check on attendance of teachers… (HL)

5.5.1.3. About School X

School X is an average achieving school located at about 20km north of Cape Coast city. The primary occupation in the area where the school is located is farming. The school has a student population of about three hundred. The school has six grade levels at the primary school (grades 1 to 6). This school practices class teaching from grades one to three and subject teaching from grades four to six.

According to the headteacher of the school (HX), the school accepts the use of OOSM in the teaching of ISM, because it is part of mathematics. She also perceived OOSM as being important for mathematics pedagogy, because “it [out-of-school mathematics] is good for children, it can help them when they further their education, they can do better” (HX). This school had the most culture-related perceptions about the links between culture and mathematics pedagogy (see Table 5.3).

5.5.1.4. About School W

School W is an above average achieving school located at about 25km north of Cape Coast city. The primary occupation of the people in the community where the school is located is farming. Like all the other schools, this school also has six grades at the primary level. The school has students’ population of about three hundred. The school practices class teaching at all grade levels.

According to the headteacher of the school (HW) the school accepts the use of OOSM in ISM. However, interviews with HW appeared to show that parents’ participation in students’ learning is restricted to demonstration in lessons on culture and history, “well during some topics they [teachers] invite parents to assist, like when they are installing a King, I mean things concerning culture and history, they bring them in,” [but not in mathematics] “the way the books are written, and the teachers are trained, they are aware of all those things [OOSM], so we do not need the town people. This is what we think.”(HW)

In this Chapter the findings concerning the headteachers' and teachers' perceptions about mathematics were presented under four areas of perceptions. These were perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between culture and mathematical knowledge, and perceptions about links between culture and mathematics pedagogy. The analysis of the data revealed that despite their different roles in the school, the majority of the headteachers and teachers had culture-free perceptions about mathematical knowledge. Their perceptions about mathematics pedagogy were also not culture-related. However, they had culture-related perceptions about links between culture and mathematics pedagogy. Also, trends toward culture-related perceptions about links between culture and mathematical knowledge were observed.

Also presented in this chapter were the conclusions from the interviews with headteachers of ten schools, made up of a mix of schools that had more culture-related perceptions and those that had less culture-related perceptions about links between culture and mathematics pedagogy. From within these ten schools, four focus schools were selected to explore how culture influences students' mathematical conceptions and practices across these four schools. The characteristics of these four schools were presented at the end of this chapter, and the next chapter will present detailed information collected from the four focus schools.

Chapter Six - Results from the Four Focus Schools

In this chapter, the results concerning some of the sociocultural influences on Ghanaian students' mathematics learning, as well as their transition experiences between contexts of mathematical practices (home and schools) from interviews and documents in the four focus schools will be presented. These four focus schools involved a school that had divided perceptions on the use of ISM in OOSM (School C), a school that discourages the use of OOSM in ISM (School L), a school that appeared to have the most open perception about the use of OOSM in ISM (School X) and a school that prohibits parents' participation in students' mathematics learning in school (School W). See Section 5.5.1 for further details about contexts of each of the schools.

In order to explore how students' mathematical conceptions and practices reflects their perceptions and those of their teachers and headteachers, the presentation of the findings in this chapter will start with the findings relating to the students' activities at home and in school. This will be followed by results relating to students' perceptions about mathematics and their parents' knowledge, research participants' language use and language preferences, the use of OOSM in ISM, cultural differences students bring with them in mathematics lessons, and parents' and teachers' collaboration in students' mathematics learning in each school.

The findings will be presented according to school types. This will enhance comparison of the findings from the various research participants within each school. It will also ensure logical presentation of the findings. The findings from the three schools which exemplify the various views about the use of OOSM in ISM (C, L and X) will be presented first (in that order). This will be followed by the results from school W, which represents the situation of lack of parents' and teachers' collaboration in students' mathematics transition. The researcher wishes to remind readers that in this study these focus schools were drawn mainly to investigate how culture influences students' mathematical conceptions across these contexts but not necessarily to treat each as a case study.

Students' activities consisted of out-of-school and in-school tasks. These sets of tasks covered four areas of conceptions. These areas of conceptions were identifying and comparing fractions, division of fractions, and measurement of capacities, multiplication of fractions, and measurement of capacity, and addition of fractions, and measurement of area (see Appendix G, Part II and Appendix H). Students' activities on identifying, and comparing fractions consisted of two tasks (Task1 and Task II). Task I covered identification, and comparing of one-sixth and one-fifth (unit fractions), whereas Task II covered identification, and comparing of half and three-fifths.

Activities on division of fractions, and measurement of capacities in out-of-school and in-school Task III in all the schools except School C covered 10.5 cups divided by three (from the use of local units of measure) or 4.2kg divided by three (from the use of measuring scale). In School C the in-school Task III for grade six students covered nine divided by three (from the use of margarine cup) or 3.6 kg divided by three (from the use of measuring scale). Task III for the grade four students covered 10 cups divided by three (from the use of local units of measure) or 4.0kg divided by three (from the use of measuring scale). The difference in the in-school task for the two groups of students at home was due to a mistake the researcher made in measuring rice for both grade six and four students before the activities.

Activities on multiplication of fractions, and measurement of capacity (Task IV) covered multiplication of 6.5 times three in out-of-school task (through cultural activity of measuring using "Olonka"). The in-school task covered multiplication of 5.5times three, using word problem solving.

Activities on addition of fractions, and on measurement of area (Task V) in the out-of-school task covered addition of two quarters (quarter plus quarter), and finding the area of a two and a quarter by two rectangle. The in-school task covered addition of two-quarters and a quarter, and finding the area of 2cm by 3.5cm rectangle (see Appendix H).

6.1 School C

In this section the findings in School C (an average school, with divided perception about the use of OOSM in ISM) will be presented. The findings will be presented in six sub-sections (6.1.1 to 6.1.6). These involve findings from focus group interview sessions with 4 grade six and 4 grade four students, as well as individual interview sessions with their teacher (same teacher for both grade levels; TC) and the headteacher (HC) of the school. Thus the interview results will be presented in Sections 6.1.1 to 6.1.6.

6.1.1 Children's Activities

In this section the results on how both grade four and six students experienced the concepts described in Section 6 above at home and school contexts will be presented.

6.1.1.1 Children's activities at home: Identifying and comparing fractions.

Out-of-school task (see Appendix H1, Tasks I and II, and Appendices N and O)*:* The findings from the children's activities at home are presented in Table 6.1.1. The results show that students had difficulty identifying unit fractions in the out-of-school task (see Appendix N). Neither the grade four nor the grade six students were able to identify one-sixth, whilst only one of them (SC62) was able to identify one-fifth. The results further show that all grade four students identified the two fractions using the same fraction name whilst half of the grade six students also identified the two fractions using the same fraction name.

Table 6.1.1. Identification of one-sixth and one-fifth by students from School C at home

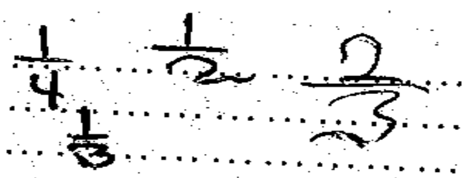
Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SC61	one-quarter	one-quarter
	SC62	half	one-fifth
	SC63	two-thirds	one-fourth
	SC64	one third	one-third
Four	SC41	quarter	quarter
	SC42	quarter	quarter
	SC43	quarter	quarter
	SC44	quarter	quarter

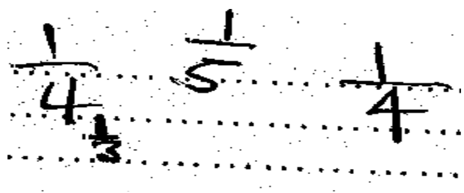
Students provided their written responses as shown in Figure 6.1.1.

Glass A1

Glass B1

Grade six students





Grade four students

quarter.......................................quarter.

Figure 6.1.1. School C students' presentation on identification of fractions in out of school task 1 at home.

However, when the two sets of glasses (A1 and B1) (see Appendix N) with their contents were presented to both sets of students to compare, one would have expected SC61 and SC64, and all grade four students to say that they are equal, but all of them identified the content of Glass B1 (one-fifth) as being more than Glass A1 (one-sixth).

Table 6.1.2 presents students' responses concerning identification of the contents of Glass A2 (half) and Glass B2 (three-fifths) at home (See Appendices H1, Task II and O). The findings from Table 6.1.2 show that none of both grade six and four students was able to identify three-fifths (Glass B2). However all grade six students and the majority (3 out of 4) of the grade four students were able to identify half (content of Glass A2). The findings show further that the majority (3 out of 4) of the grade six students once again used the same fraction name to identify the two fractions.

Table 6.1.2. Identification of half and three-fifths by students from School C at home

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SC61	Half	Half
	SC62	Half	Half
	SC63	Half	Two-thirds
	SC64	Half	Half

Table 6.1.2. (continued)

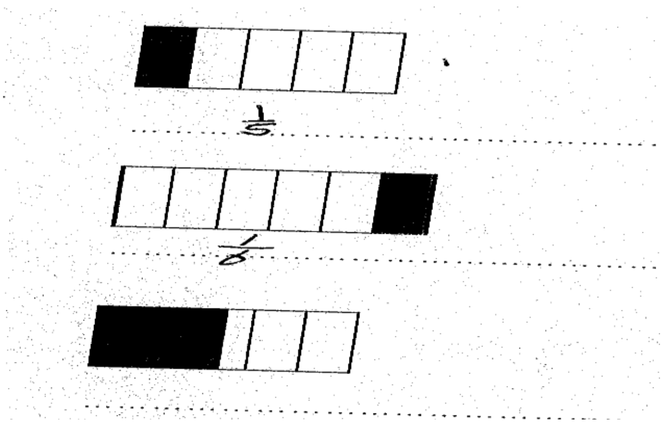
Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Four	SC41	Half	Quarter to full
	SC42	Half	No idea
	SC43	Quarter	Half
	SC44	Half	More than half

However when the contents of the two glasses (see Appendix O) were presented to grade six students to compare all of them said the content of Glass B2 was more than Glass A2 All grade four pupils also identified the content of Glass B2 as being more than A2.

The results appear to show that to some of the students a quarter (SC61) and one-third (SC64) do not represent exactly a fourth, and a third of a whole respectively (are not fixed). They could be more or less, as they identified the content of both glasses A1 and B1 as a quarter and one-third respectively in Task I but said that both are the same. Also the results showed that to the students, half could be either the exact midpoint (all children), or above the midpoint (SC61, SC62 and SC64) or even below the midpoint (SC62; from Task I and Task II). Thus in their conception, a half does not always represent the exact mid-point (is also not fixed). The most common fraction name that was used often in all the two out-of-school tasks relating to the identification of fraction (Task I and Task II) by grade six students was half (eight times). This was followed by a quarter (three times). The most common fraction name that was used in Task I and Task II by grade four students was a quarter (nine times), followed by a half (four times).

In-school task (see Appendix H02, question number 1(a)): The findings from in-school task on fractions also showed that both grade six and four students had difficulty identifying fractions. They tended to concentrate on the number of partitions in the whole and the shaded portion to decide on what fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole. For example in identifying one-fifth, they counted five divisions and one shaded portion, and presented their answers as one-fifth. They were therefore able to identify one-sixth and one-fifth, in the in-school Task1, without problems. They, however, had difficulty identifying half (a fraction they were able to identify in the out-of-school task) in in-school Task II. This was because they could not easily figure out the number of divisions, as shown in Figure 6.1.2. It can be seen from Figure 6.1.2 that Grade four students identified it as half out of five whilst the grade six students could not attempt it at all.

Grade six students' presentation



Grade four students' presentation

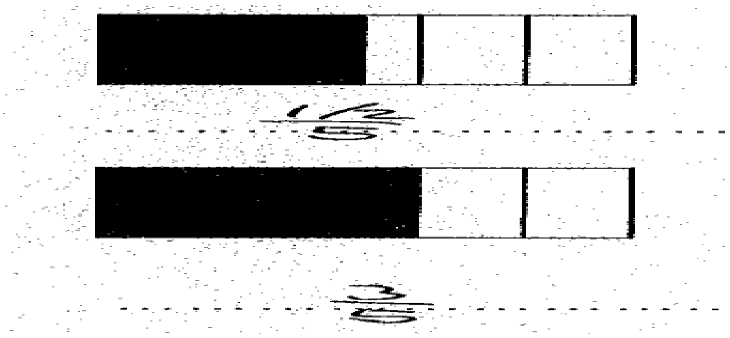
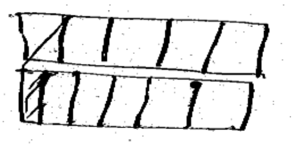


Figure 6.1.2. School C students' presentation on identification of fractions in-school task II at home.

This is an indication that their notion of part-whole relationship in fractions in school is limited to number of shaded portions divided by number of divisions, instead of relationship between the whole and the shaded portion of the whole.

In comparing fractions (see Appendix H02, question number 1(b)) both sets of students used the correct symbols to compare all fractions. However, grade six students had difficulty justifying their answers. For instance, the grade six students were able to indicate that one-fifth was greater than one-sixth, but justified their results using wrong diagrams, as shown in Figure 6.1.3. Also they (grade six students) were able to indicate that three-fifths was greater than three-sixths, but could not justify their answer at all. Grade four students also drew diagrams to justify each of their results, as shown in Figure 6.1.3.

Grade six students' presentation



Grade four students' presentation

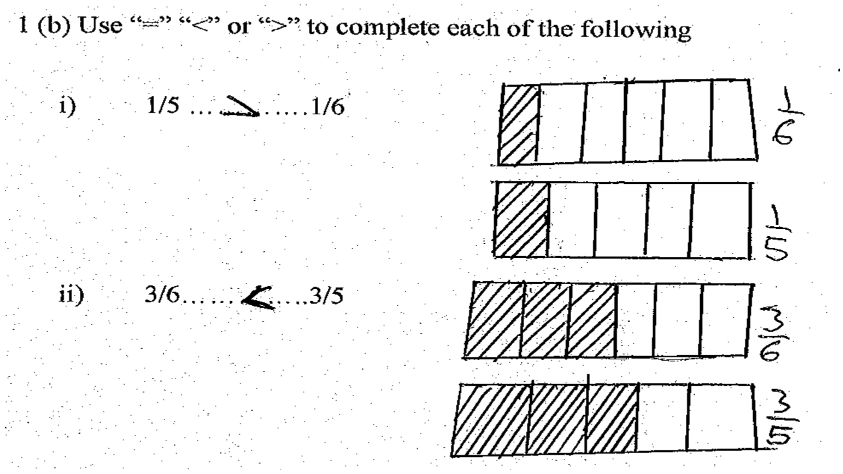


Figure 6.1.3. School C students' presentation on comparing fractions in in-school task at home.

It is evident from diagrams in Figure 6.1.3 that partitioning of wholes by students was done unequally. This makes it difficult for one to compare each of the two fractions from their diagrams. This is an indication that sharing/dividing in fractions, as far as these students are concerned, did not mean dividing equally.

6.1.1.2 Children's activities at home: Division of fractions/measurement of capacities.

Out-of-school task (see Appendix H01, Task III): Both sets of students approached their solution in the out-of-school task in an informal way, using a margarine cup as a unit of measure. However, the approach the two sets of students used in sharing 10.5 cups of maize differed.

Grade six students set three containers and went round each of these containers with a cup of maize, to find out what each one would get before finding the total number of cups of maize, through oral computation, as shown in the excerpt from the interviews below:

SC62: [with the help of other group members, puts one margarine cup of maize in each of the three containers; they go round for the second and the third times.]

SC61: what is left is too little for each container to get one cup

SC62: [goes round the three with a half cup after giving each a half cup the whole thing gets finished.]

Students: each of them will get three and a half cups [chorus], [which was the correct answer].

R: so how much maize was there in the bag?

SC62: let's add them up,

Students: [silent for a few minutes] it is ten and half cups [chorus]

SC64: [present their solution in a diagram as shown in Figure 6.1.4 below.]

However, grade four students approached the sharing differently. They shared unequally; their perceived eldest had more whilst the youngest had the least (see

Appendix P, Table P01). Also they described their process in prose, without any diagrams, and rounded their answer, as shown in the excerpts from interviews below.

SC42: [picks three empty containers, puts one in front of SC44, SC43 and SC41, on a table. Using the margarine cup as a unit of measure, SC42 puts one cup of maize in each of the containers. She goes round the second time and third times. She then measures one cup and gives it to SC41, puts the rest in the margarine cup (that measured half), and gives it to SC43 and leaves SC44 with three cups.]

R: SC42 why have you shared it this way?

SC42: [explains in Fante] because all of them cannot get four; SC41 is older than the two of them, so she takes four, and SC43 is older than SC44, so he takes three and the remaining. SC44 takes three, because she is the youngest among them [NB: at this stage students were not aware of the ages of other group members]

R: do you all agree?

Students: [all, including SC44] yes we do

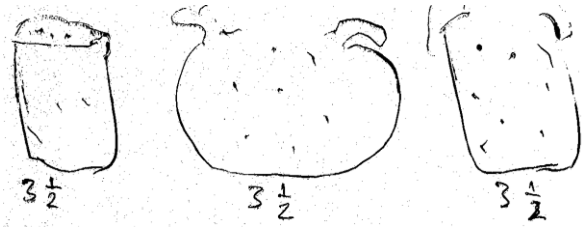
R: so what is the total amount of maize in the container?

Students: eleven cups [instead of ten and half cups], [chorus]

R: write down your solution on your worksheet

Children: [SC41 presents their solution as shown in Figure 6.1.4.]

Grade six students' presentation



Grade four students' presentation

Task III

Share the given ~~palm fruits~~ maize among three children who assisted on a farm

(a) Measure and tell the total amount of ~~palm fruit~~ maize

…11…………………………………………………………………………………

……………………………………………………………………………………………

(b) Share the ~~palm fruits~~ maize among the three children and tell how much each child will get four four three

(c) Write your solution on the worksheet

We use Olonka to measure When we measure it two people get four and one person get three.

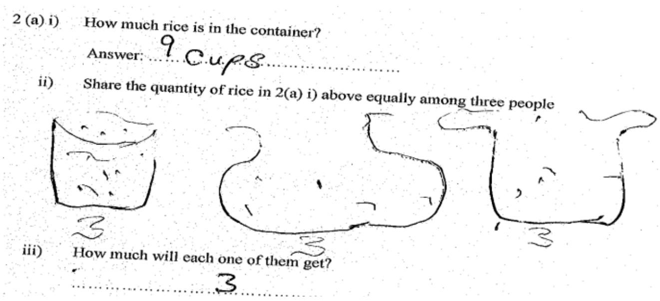
Figure 6.1.4. School C students' presentation of 10.5 divided by three in out-of-school task at home.

In-school task (see Appendix H02, 2(a)): As with the out-of-school task, the students approached their solution to the in-school task in an informal way, using a margarine cup. They approached the sharing in the same way they did in the out of school task at home.

Grade six students found what each one person would get, before finding the total number of cups of rice through oral computation. They presented their solution as shown in Figure 6.1.5

As usual grade four students' shared according to seniority, SC42 was given four cups whilst SC43 and SC44 were each given three cups. This was despite the word “equally” being used in the in-school version of the task (see Appendix H02, 2(a)). They used both prose and mathematical sentences to present their solution, as shown in Figure 6.1.5. SC42 was given four because, “SC42 is older than the two of them.” (SC41)

Grade six students’ presentation



In both cases, the grade six students did not provide any written computation; oral computations and diagrams were used to explain their thinking and their final answer.

Grade four students’ presentation

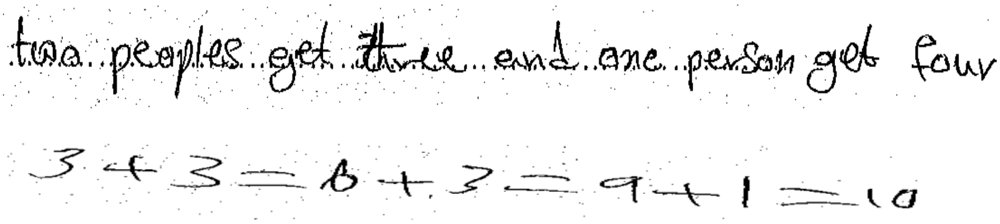


Figure 6.1.5. School C students’ presentation of solution to in in-school task at home.

6.1.1.3 Children’s activities at home: Multiplication of fractions/measurement of capacity.

Out-of-school Task (see Appendix H01, Task IV): Students approached their solution informally, by calling out their answer first, and then providing oral computation in support of their answers. They provided written presentation of their answer once they were requested to do so.

Thus in solving the problem which required them to determine how many cups of maize was there in three “Olonka” (Task IV) both grades four and six began by calling out the answer as, “nineteen and half” (chorus), which was the correct answer. SC62 provided oral explanation as, “six and half plus six and half gives thirteen, and thirteen plus six and half, gives nineteen and a half” (SC62). SC64 presented the group’s solution using mathematical equation, as shown in Figure 6.1.6. SC42 also presented grade four students’ solution using decomposition method, as shown in Figure 6.1.6.

Grade six students’ presentation

$$6\frac{1}{2} + 6\frac{1}{2} + 6\frac{1}{2} = 19\frac{1}{2}$$

Grade four students’ presentation

$$6 + 6 = 12 + 6 = 18 + 1\frac{1}{2} = 19\frac{1}{2}$$

Figure 6.1.6. School C students’ presentation of 6.5 times three in out-of-school task at home.

In-school Task (Appendix H02, 2(b)): Whilst the grade six students were able to solve the word problem, which involved the product of 5.5kg and 3, grade four students couldn’t attempt it. Grade six students approached using an informal approach. They read the question in English, and discussed it in the local language for a while, SC61 finally called out the answer as 16.5. She justified their answer using oral computation, in the local language as, “it would be five point five thrice, five thrice is fifteen, and zero point five thrice is one and half, so that will give us sixteen and half,” but presented only their answer as “Esi buy [sic] 16.5,” without any mathematical equation.

Grade four students couldn't attempt the word problem. Student SC42's comment "we do not understand the question" was echoed by his peers. They had difficulty reading, and understanding the question. Some of the difficult words included "quantity" and "times". They read "times" as "types", so they interpreted the question (in the local language) to mean "Esi bought three types of rice". They were not sure whether it was a mathematics problem or an essay, "it must be an essay question" (SC42).

6.1.1.4 Children's activities at home: Addition of fractions and measurement of area.

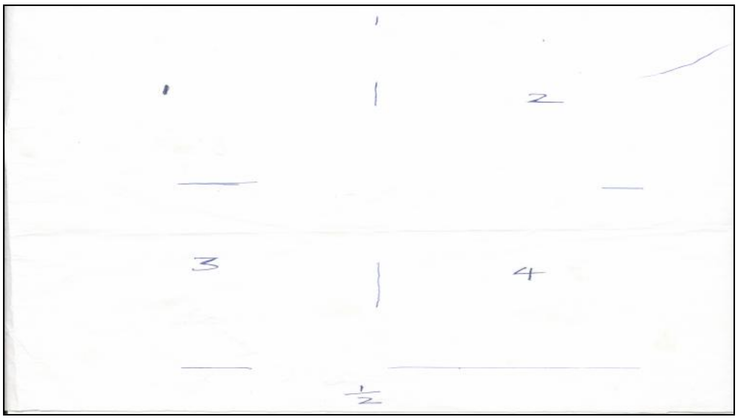
Out-of-school task (see Appendix H01, Task V): Grade six students were able to add fractions and measure the area of a rectangle, through local activities of measuring using "poles" (as unit of measure) in this task (Task V). Through these activities students were able to add two quarters, to arrive at the correct answer as a half. They were also able to measure and find the area of two and a quarter unit by two unit rectangle correctly, as four and half "poles", as shown in the excerpts of the interviews below.

R: [provides students with 24cm by 27cm rectangular sheet, as an area of a citrus farm, and 12cm by 12cm square paper, as a "pole" of land. He then asks students to find how many "poles" are there in the citrus farm?]

Students: [using 12cm by 12cm unit squares, they measure four poles; in measuring the remaining area they divide the remaining area into two, and use the 12 by 12 square to measure the two quarters to get a half and write their answer as $4\frac{1}{2}$, as shown in Figure 6.1.7]

In Figure 6.1.7, the number 1 represents the first pole area measured, 2 the second, 3 the third and 4 the fourth pole areas measured, whilst $\frac{1}{2}$ was the remaining pole area measured.

Grade six students' presentation



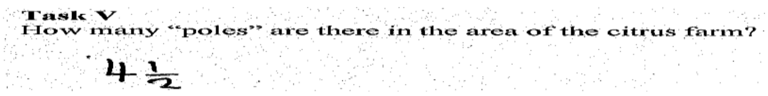

Task V
How many "poles" are there in the area of the citrus farm?
$4\frac{1}{2}$

Figure 6.1.7. School C students' approach to measurement of two by two and a quarter pole area at home.

Unlike the grade six students, the grade four students measured four poles and ignored the remaining parts. They therefore rounded their answer as four poles, and presented their solution in prose as "there are four poles in the area of the citrus farm."

In-school task (see Appendix H02, 3(a) and 3(b)): Both sets of students had difficulty adding quarters in this activity (Appendix H02, 3(a)). Even though grade six students added quarters correctly using everyday activities involving "poles", they had difficulty adding the fractions in the in-school activities. In solving the question, they kept code switching from English to the local language, and ignored the suggestion from a lower achiever (which was the correct approach), as shown in the excerpts from interview below:

> **SC62** (lower achiever): [reads the question, all of them join in]
>
> **SC62**: [tries to explain in Fante] it is plus
>
> **SC61** (higher achiever): it is times
>
> **SC63 and SC64**: [nod in agreement to times]

R: Both of you should present your solution.

SC62: [Presents solution, as shown in Figure 6.1.8]

SC61: [Presents solution, as shown in Figure 6.1.8]

Grade four students correctly interpreted the demands of the question as a quarter plus two-quarters, after which SC44 orally said, “three-eighths.” SC42 presented the group’s solution in prose as “there are $\frac{3}{8}$ orange”.

SC62’s presentation

$$\frac{1}{\cancel{4}_2} + \frac{\cancel{2}^1}{4} = \frac{1}{2} \text{ of } \frac{1}{4} = \frac{1}{8}$$

Although SC62 interpreted the question correctly as involving addition of fractions, she could not solve it through employing the school technique of solving addition of two like fractions to solve.

SC61’s presentation

$$\frac{1}{\cancel{4}_2} \times \frac{\cancel{2}^1}{4} = \frac{1}{2} \times \frac{1}{4} = \frac{1}{8}$$

SC61’s interpretation was wrong, however, she knew the technique for solving multiplication of fraction in school.

Figure 6.1.8. School C students’ presentation of solution to a quarter plus two-quarters.

Also, students were not able to solve problem involving the area of a rectangle in the in-school task (see Appendix H02, 3(b)), even though they were able to solve a similar problem in the out-of-school task. In solving the in-school task, which involved finding the area of 2cm by 3.5cm rectangle, students read question (chorus). SC61 called out the answer as seven (which was the correct answer). When they were requested to show working, SC63 quoted formula for finding the area of a rectangle. They solved the problem using the formula, but they arrived at the wrong answer as 6.5cm, as shown in Figure 6.1.9. They accepted the wrong answer (6.5cm) and rejected their previous answer of seven from their oral computation (which was correct).

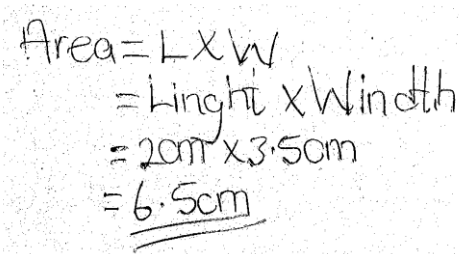


Figure 6.1.9. School C students' solution to finding the area of 2cm by 3.5cm rectangle at home.

It can be observed that no mathematical equations were provided in the case of measurement of area in out-of-school Task V.

6.1.1.5 Students' activities in School: Identifying and comparing fractions.

In Sections 6.1.1.5 to 6.1.1.8 the results of students' activities in school will be presented. The tasks students went through at home were the same task they were given in school. Students' activities in school also covered four areas, namely identifying and comparing fractions, division of fractions/measurement of capacities, multiplication of fractions/measurement of capacity, and addition of fractions and measurement of area. However, in-school Task III for grades six and four students in students' activities in-school covered 10.5cups divided by three (from the use of local units of measure) or 4.2kg divided by three (from the use of measuring scale), (instead of nine cups divided by three and ten cups divided by three for grades six and four students respectively, see Section 6 above). Results from students activities in school are presented below, based on these four areas.

Out-of-school task: Table 6.1.3 presents the findings from the identification of one-sixth and one-fifth by both grade four and six students. The findings from Table 6.1.3 also show that both grade four and six students had difficulty identifying unit fractions in the out-of-school task, in school. None of them was able to identify one-sixth and one-fifth in Task I. As with their activities at home, half of the grade six students used the same fraction name to identify the two fractions. Whilst all the grade four students also used the same fraction name to identify the two fractions.

Table 6.1.3. Identification of one-sixth and one-fifth by students from School C in school

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SC61	Quarter	Quarter
	SC62	Quarter	Two-thirds
	SC63	Quarter	Two-fifths
	SC64	Quarter	Quarter
Four	SC41	Quarter	Quarter
	SC42	Quarter	Quarter
	SC43	Quarter	Quarter
	SC44	Quarter	Quarter

When students were asked to compare the contents of the two glasses (A1 and B1) (see Appendix N), one would have expected all but SC62 and SC63 to say that they are equal, however, all grade six and four students said the content of Glass B1 (one-fifth) was more than Glass A1 (one-sixth).

Responses from students' activities on the identification of half and three-fifths are summarised in Table 6.1.4. The results from Table 6.1.4 show that all grade four students and the majority (3 out of 4) of grade six students were able to identify the content of Glass A2 correctly as a half. They however had difficulty identifying the content of Glass B2 (three-fifths). Grade four students had difficulty naming the content of Glass B2 (three-fifths). SC42 explained "more than half" as, "it is more than half but not up to full."

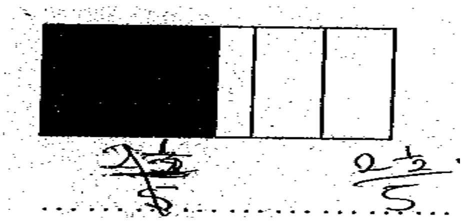
Table 6.1.4. Identification of half and three-fifths by students from School C in school.

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SC61	Half	One over three
	SC62	Two-thirds	Half
	SC63	Two-fourths	Two-thirds
	SC64	Two-fourths	Two-thirds
Four	SC41	Half	More than half
	SC42	Half	More than half
	SC43	Half	More than half
	SC44	Half	More than half

When the contents of the two glasses were presented to students to compare, both sets of students said the content of Glass B2 was more than Glass A2. The findings also show that the most common fraction name that was often used by grade six students in both Task I and Task II was a quarter (six times).The most common fraction names that were used often by grade four students were a quarter and a half (eight times and four times respectively).

In-school-task: Findings from the in-school task on fractions in school also showed that both grade four and six students had difficulty identifying fractions. They tended to concentrate on the number of partitions in the whole and the shaded portion to decide on what fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole (as already noted in Section 6.1.1.1 above). Both sets of students were therefore able to identify one-sixth and one-fifth in the in-school task1 without problems. In Task II also, they were able to identify three-fifths, but rather identified the half as two and half out of five (see Figure 6.1.10). It can be seen from Figure 6.1.10 that unlike the activity at home (see Section 6.1.1.1) where grade six students were not able to attempt the same question, this time they presented their solution as two and half out of five.

Grade six students' presentation



Grade four students' presentation

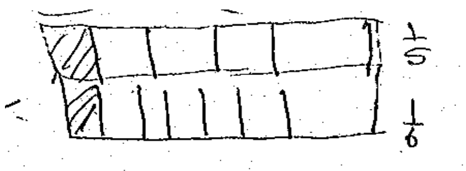
Figure 6.1.10. School C students' presentation on identification of a half in-school Task II in school.

Students' inability to identify half confirms the earlier observation (from their activities at home) that their notion of part whole relationship in fractions seems to be limited to number of shaded portions divided by number of divisions, instead of relationship between the whole and the shaded portion of the whole.

As with their activities at home, in comparing fractions both sets of students used the correct symbols to compare all fractions, but had difficulty justifying their answers. For instance grade six students were able to indicate that one-fifth was greater than one-sixth, but justified their results using wrong diagrams, as shown in Figure 6.1.11. A look at Figure 6.1.11 shows clearly that what grade six students were showing as one-sixth was actually divided into seven unequal parts.

Also grade six students were able to indicate that three-fifths was greater than half but they could not justify their answer. It could be seen from Figure 6.1.11 that grade four students also divided wholes unequally.

Grade six students' presentation



Grade four students' presentation

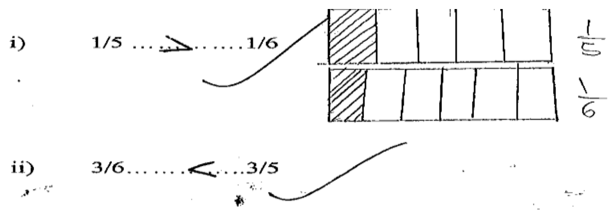


Figure 6.1.11. School C students' presentation on comparing fractions in in-school task in school.

6.1.1.6 Students' activities in School: Division of fractions/measurement of capacities.

Out-of-school Task: As with the activities at home, both grade six and four students approached their solution in an informal way. They requested a margarine cup as a unit of measure. They then found what each person would get, and orally called out the total number of cups of maize in the bag as ten and half cups. However, as with the activity at home, grade six students shared equally as shown in the excerpts from interviews below:

SC62: [leads discussion; with the help of other group members, she sets three things comprising of an empty tin and two rubber bags on a Table. She puts one margarine cup of maize in each of the three things; goes round for the second and the third times. After the third time they go round the three with a half cup, after giving each a half cup the whole maize gets finished]

Students: Each of them will get three and half cups [chorus]

R: so how much maize was there in the bag?

Students: [orally] it is ten and half cups [chorus]

SC64: [present their solution in diagrams as shown in Figure 6.1.12]

Grade four students shared according to ages, however, unlike the activities at home, this time the conditions for sharing changed as the students had information about their ages (NB: the researcher collected participants' ages in school), as shown in the excerpts of the interviews below:

SC42: [puts three empty containers, one in front of SC44, SC43 and SC41, on a table. Using the margarine cup, she measures one cup of maize and puts in each container. She goes round the second time and the third time. She then measures one cup and gives it to SC41, and keeps the rest in a margarine cup (that measured a half cup).]

R: what about the half cup?

SC42: [explains in Fante] It is the remainder; it is too small for me to share it among them. I cannot give it to either of them [referring to SC44 and SC43] because they are of the same age and if I give it to SC41 that would be too much, so I will keep it

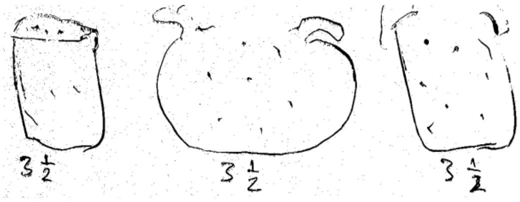
R: so what was the total amount of maize in the container?

Students: [orally say] ten and half [chorus]

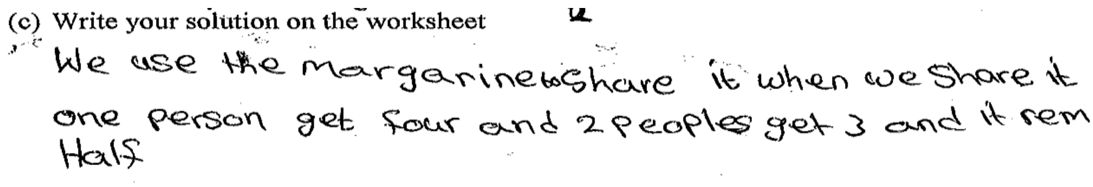
R: write down your solution on the work sheet

SC41: [presents their solution as shown in Figure 6.1.12.]

Grade six students' presentation



Grade four students' presentation


(c) Write your solution on the worksheet

We use the margarinewShare it when we Share it one person get four and 2 peoples get 3 and it rem Half

Figure 6.1.12. School C students' presentation of 10.5 divided by three in out-of-school task in school.

In-school Task: Both sets of students approached their solution in an informal way. They requested a margarine cup as a unit of measure and found what each one would get, by going round each of the three containers with a margarine cup of rice, as in the case of out-of-school activities. They found the total number of cups of rice through oral computation. However, whilst grade six students shared equally, grade four students shared according ages (as usual). Unlike the out-of-school task, and in-school task at home, Grade six students provided a mathematical equation to support their answer, as shown in Figure 6.1.13. As with the out-of-school task (see Figure 6.1.12), grade four students presented their solution in prose.

Grade six students' presentation

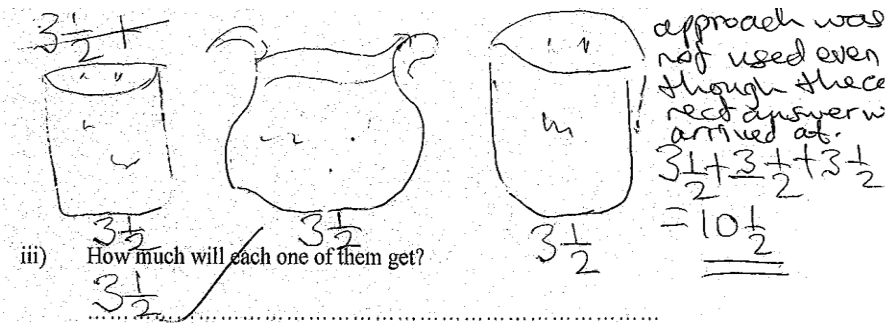


Figure 6.1.13. School C students' presentation of 10.5 divided by three in out-of-school task in school.

6.1.1.7 Students' activities in school: Multiplication of fractions/measurement of capacity.

Out-of-school Task: An "Olonka" full of maize was presented to students, as a share of one of three children, and they were asked to find the total number of margarine cups of maize these children shared (see Appendix H01, Task IV). As with the out-of- school task at home, both grade six and four students used the informal approach of mentioning the answer as, "nineteen and a half" (SC61; SC42), and orally explaining their solution as, "six and half plus six and half gives thirteen, and thirteen plus six and half gives nineteen and a half." (SC63) As with the activities at home, SC62 provided grade six students' written solution as a repeated addition of six and half (see Section 6.1.1.3), whilst SC41 presented grade four students' written solution using the decomposition method of adding, similar to grade four students' presentation in Figure 6.1.6 above.

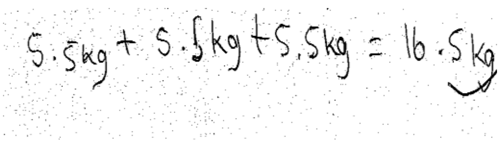
In-school Task: Grade six children approached the task using a similar informal approach, as in the activities at home (Section 6.1.1.1). However unlike the in-school task at home, they provided mathematical sentence to support their solution, as shown in the excerpts from interview below:

Students: [read question, chorus]

SC61: [orally explain in Fante] it would be five point five thrice, zero point five plus zero point five plus zero point five is one and half; five plus five plus five plus five is fifteen, so that will give us sixteen and half. [She presents the group's solution as shown in Figure 6.1.14.]

As with the activities at home, grade four students had difficulty reading the word problem. They could not figure out the demands of the question, so they could not attempt the question. However, when the researcher wrote "5.5kg x3" on a sheet of paper for them to solve, they were able to solve that without problems, as shown in Figure 6.1.14.

Grade six students' presentation



Grade four students' presentation

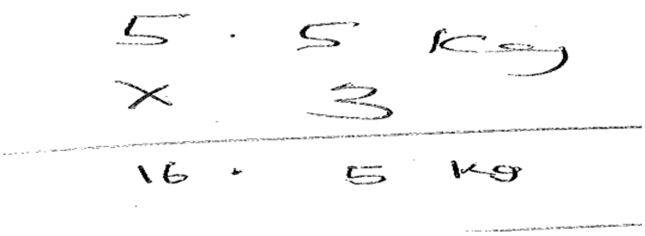


Figure 6.1.14. School C students' presentation of 5.5 times three in in-school task in school.

6.1.1.8 Students' activities in School: Addition of fractions and measurement of area.

Out-of-school task: Like their activities at home (Section 6.1.1.4), grade six students were able to add fractions, and measure the area of a rectangle, through the traditional activities of measuring using "poles" (as unit of measure). They followed the same approach described in section 6.1.1.4 above. Through these activities, students were able to add two quarters to arrive at the correct answer as half. They were also able to find the area of two and a quarter unit by two unit rectangle correctly, as four and half poles. However, grade four students measured four poles, and then guessed what was remained as a quarter. They wrote their final answer in prose as “we get [sic] four poles and quarter.”

In-school task: As with their activities at home, both grade six and four students had difficulty adding the fractions in the in-school task in school. In solving the question, the grade six students kept code switching from English to the local language, and ignored the suggestion from a lower achiever (which was the correct approach), as shown in the excerpts from interview below:

> **Students**: [Read the question chorus, discuss in Fante….]
>
> **SC62**: it is plus
>
> **SC61**: it is times
>
> **SC63 and SC64**: [as usual nod in agreement to times]
>
> **SC62**: [remains silent]
>
> **SC61**: [present their solution wrongly, as shown in Figure 6.1.15.]

Grade four students were able to read and interpret the demands of the question correctly, as involving addition. However, they got divided over their answer. SC41 orally said, “it is three-quarters; he gave a quarter to Abena and two-quarters to Akua,” SC42 said, “it should be three-eighths.” SC41 and SC42 presented their solutions as shown in Figure 6.1.15.

Grade six students' presentation

$$\frac{1}{24} \times \frac{\cancel{2}}{4} = \frac{1}{2} \times \frac{1}{4} = \frac{4}{6}$$

Grade four students' presentation

SC41's presentation

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$$

SC42's presentation

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{8}$$

Figure 6.1.15. School C students' presentation of answer to a quarter plus two quarters in in-school task in school.

As with the activities at home, grade six students had difficulty finding the area of the rectangle. They followed the informal approach of mentioning the answer as, "seven" (SC61), this was followed by written computation using the formula for finding the area of a rectangle, to arrive at their wrong answer, as shown in Figure 6.1.16.

Grade six students' presentation

Area =
L × W
Lenght × Width
3.5cm × 2cm
$= 6.5cm^2$

Figure 6.1.16. School C students' presentation of solution to finding the area of 2cm by 3.5cm rectangle in school.

For both the Out-of-school and In-school Tasks at home and in school, both grades six and four students used the local language in communicating amongst themselves.

They mainly used the same language in communicating with the researcher. With the exception of SC64 and SC42 who said they thought in English; “I think in English,” (SC64); “me I use English in thinking.” (SC42), all student participants said they thought in the local language (Fante), as they went through the activities, “I think in Fante.” (SC43), “Fante.” (SC61) This was evident in their solution to word problem solving. They read the question in English, discussed in Fante and presented their solution on the worksheet in English.

6.1.2 Students’ Perceptions

6.1.2.1 Students’ perceptions about mathematics.

Findings from focus group interviews with both grade six and grade four students showed generally culture-related perceptions about mathematics (especially amongst grade six students). All grade six students identified pictures of “a local market woman selling rice”, “a driver’s mate”, “a farmer” and “a Kente/twil weaver” as people who use mathematics. Interviews with grade four students also revealed that with the exception of “driver’s mate” and “an engineer”, they identified all the pictures; including “a local market woman selling rice”, “a farmer” and “a Kente/twil weaver” as people who use mathematics.

The two sets of students perceived OOSM and ISM differently. Grade six students perceived OOSM as being different from ISM, “what we learn in school is not the same as home” (SC63), “in school mathematics is studied in English, but home mathematics is carried out in Fante” (SC62). Grade four students believed the two are the same. Student SC42’s response “they [OOSM and ISM] are the same mathematics,” was echoed by his peers. However, they perceived that OOSM is for home, whilst ISM is for school, “... we use kilogrammes in school, and learn margarine cups at home.” (SC42) They also perceive OOSM is done in the local language, whilst ISM is done in English, “home mathematics is in Fante, and the school mathematics is in English.” (SC42)

Grade six students valued ISM more than OOSM, “school mathematics is important, school mathematics has some English; we are kids, we need to learn English.” (SC61) Even though all perceived OOSM as a form of mathematics, they perceived it as having no relationship with ISM. As with the grade six students, half of grade four students (SC41 and SC42) valued ISM more than OOSM, “…it is better to learn English Mathematics.” (SC41) The other half (SC43 and SC44) perceived both as being important, “both are important for daily use.” (SC44)

Students, however, associated ISM with the educated, “the educated; teachers, Engineers, nurses, doctors.” They associated OOSM with the unschooled, and the less educated, “farmers, traders, drivers.”

6.1.2.2 Students' perceptions about parents' knowledge.

Findings from interviews with grade six students showed that the majority (3 out of 4) of them devalued their parents' mathematical knowledge, “They don't know anything,” (SC62) “they don't know mathematics,” (SC64) SC64's dad teaches him mathematics at home but according to him “...what dad teaches me is different from school, when I come to school they don't ask me to count stones and sticks, but dad asks me to do that, it is different.”; “they[parents] know different kind of mathematics.” (SC63) Only one appeared to value her parents' mathematical knowledge, “they know some mathematics, but not all.” (SC61)

All grade six students, however, appeared to see some worth in their parents mathematical practices, “Their mathematics is not like ours but it is not bad, they count, they can give change and so on,” (SC61) it [parents mathematical practices] is good, but not too good, what we can do in school, they cannot do it at home...” (SC63)

Responses from interviews with grade four students showed all of them as saying their parents' mathematical practices are different from what they experience in school, “my parents’ mathematical practices are different.”(SC43) According to students, “they [parents] do their mathematics orally.” (SC42)

6.1.3 Language Use and Preference

6.1.3.1 Students’ language use and preference.

Results from interviews with both grade six and four students showed that English appears to be the language for school. All grade six students said they use Fante in communicating with their parents, and friends at home. The majority (3 out of 4) of the grade four students said they use Fante in communicating with their parents, and friends at home. Only SC41 uses English with the parents because, “when I came from the North I could not speak Fante at all, so they speak English with me,” whilst according SC42, “me I speak English with my friends ..., we want people to know that we can speak English.”

Language use in class differed amongst grade six and four students in school. Grade six students use English in class, whether there are lessons or no lessons. According to these grade six students, they communicate with their teacher and classmates in English because, “we are in school” (SC61), SC61’s comment was also echoed by her peers. They said they use English in communicating with classmates and teachers during break time, because “... we are in the school, if you don’t speak it [English language] you would be punished.” (SC63) Grade four students use English in class, when there is a lesson because, “she canes us when she hears us speaking Fante in class.” (SC41) They said they use English with the teacher and Fante with friends when there is no lesson in class. Students said they use English in communicating with teacher during break time and Fante with their friends, “English with teachers and Fante with friends” (chorus). They speak to teachers in English during break time because, “if you speak Fante she would say speak English.” (SC41)

Interviews with both grades six and four students also revealed the two sets of students as saying their teacher uses English in teaching mathematics generally, and fractions and measurement specifically.

Findings concerning their preferred language showed the grade six students as saying they preferred to study mathematics generally in English, and concepts of fractions and measurement specifically also in English language because, “when we write examinations we cannot write Fante on the paper.” (SC63) and also “because we are in school.” (Chorus)

The majority (3 out 4) of the grade four students also said they preferred to learn mathematics in English because, “we want to understand and speak English well” (SC42); “Fante wouldn’t take us anywhere, except English” (SC41). SC43 preferred Fante because, “I don’t understand lessons in English.” (SC43) SC41 and SC42 want to study fractions and measurement in English, because they want to understand and speak English well, whilst SC43 and SC44 preferred the local language, because they do not understand lessons in English. Both of them had this to say, using the local language, “I don’t understand lessons in English.”

6.1.3.2 Teacher’s language use and preference.

Results from interviews with the upper primary mathematics teacher in School C (TC) showed TC as saying students use mostly English language in class when mathematics lesson is on, “...mostly English language, but when we have to use role-play then you explain in Fante, and they act, then you get them to understand the topic better and apply it, but still with the English language.” (TC) According to TC, “when there is no lesson, they [students] normally use the L1 [Fante].” They, however, use “mixture of English language and L1,” (TC), during break time. They use English during break time, only when they see teachers around, “at times when they see the teacher, they try to speak English, but when they are on their own with their friends they speak Fante.” (TC) According to TC “... when they are outside [on break] they think they are at liberty to speak their language, that is why the moment they see the teachers they tend to speak English or they would be prompting themselves to speak it [English].”

Interviews with TC also showed her as saying she speaks English with students in class, whether there are lessons or no lessons. English is the language TC uses in teaching mathematics generally, and fractions and measurement specifically. This is because of three reasons; firstly “…it is the medium of instruction”, secondly “…the questions come in English, and we have to teach and explain in English” and thirdly “…it is the English language that we can use to explain pace, the strides and others, before we come to the standard units of measures.”

According to TC she also speaks English with students outside classroom during break time. TC believes English must be used, because, “English is the L2 [the teaching language], so I think that is what we have to use.” However, TC’s choice of language outside the school premises usually depends on the language that students use in greeting her, “… they may start greeting you by saying ‘me pa wo kyaw’ [please in English], so with that you also unaware speak the Fante to them, but some of them see you and say ‘madam, good morning’, that is English, then you also communicate with them in English.”(TC) She usually speaks Fante with students outside school premises unconsciously, not because she wants to speak Fante with them, “at times it is suddenly, you start with Fante and then you realise and turn to English.” (TC)

TC prefers students to use English in class during mathematics lesson because, “especially with word problems, and problem solving, the sentence and everything is in English language, so during mathematics lessons if they understand English language they can turn the problem to mathematical equations …” TC prefers the use of English in teaching mathematics because, “from P4[grade four] it is the medium of instruction,” and also “... lessons come with English language, and the textbook is [written] in English, so there is no way we can do away with it [English language].” TC would also prefer to teach fractions in English because:

> as I said, it is the medium of instruction, and when you are teaching fractions the key words such as divide, share, or 'take part of' are not so difficult to turn to the local language. The children are familiar with them. I don't find any problem using the English in teaching fractions. (TC)

TC would prefer to use English in teaching measurement, because "it is the medium of instruction, and then as I said, the key words or the technical words, translating may be a bit difficult." TC would prefer to mix English language with the local language even if she gets local language to explain technical terms in mathematics, "no, I would mix the two, but not shifting from the English entirely, because English language is the medium of instruction from the policy." (TC)

6.1.3.3 Headteacher's language use and preference.

According to the headteacher of School C (HC), "at the lower primary [from grade one to three] we use the Ghanaian language [Fante] in teaching mathematics, and at the upper primary that is primary 4, 5, 6 [grades four to six] we use English language." However, the local language is usually used to explain difficult concepts at all levels, "basically we use our own language, which is Ghanaian language to explain some concepts kids don't understand at all levels in primary school." (HC) The finding showed HC as also saying "basically they [students] use the local language when there is no lesson." According to HC they use same language during break time, "Ghanaian language; … same language."

Unlike the students and their teacher (TC), HC prefers the mix of English and Ghanaian language from grades four to six, as the medium of instruction:

> to use Ghanaian language at the lower primary level because at that level they would understand it better ... but in the upper primary they are a little bit grown, so I prefer the use of both Ghanaian language and English language. Ghanaian language should be used there [from grades

> four to six] for the explanation of certain concepts they think the kids don't understand. (HC)

6.1.4 The Use of OOSM in ISM

6.1.4.1 Policy influences.

Interviews with Teacher C (TC) indicated that she was aware of the language policy of Ghana, which requires the use of Ghanaian language at the lower primary and English language from the upper primary:

> from P1 to three, that is the lower primary, and now KG inclusive, the English language should be taught as a subject, whiles the L1 is used as the medium of instruction, then from P4 on wards, English language is used as a medium of instruction, as well as a subject, then the L1 becomes a subject.

According to TC the language policy of Ghana affects the use of OOSM in ISM, because the language of instruction from grade four does not permit the easy use of OOSM in ISM. This is reflected in her statement:

> … so [at the lower primary level] keeping what they have at home, "ekor"[one in English language] "ebien"[two in English], and when they come to school "ekor" "ebien", it doesn't make any difference, but when the changeover [from local language to English as a medium of instruction] comes, that is where the problem arises.

Interviews with the headteacher of School C (HC) also indicated that HC was aware of the language policy of Ghana, “the language policy states that for the lower primary they use their mother tongue, and upper primary L2, which is the English language; that is upper primary English only.” (HC) According to HC:

> it [the language policy] affects it [use of OOSM] to some extent, because not all the kids in the upper primary are conversant with the use of the English language. That is why we on the ground are saying no, if that is the case we would use English and the Ghanaian language.

6.1.4.2 Classroom practices.

Findings from the interviews with Teacher C (TC) brought to light that she makes use of OOSM in ISM, through role play:

> by role play; for example if I am teaching word problems involving addition or subtraction, then they role play, where one acts as a father or a mother asking the son to buy certain things, and give a certain amount...

According to TC, students also make use of out-of-school cultural notions in measurement, such as empty tins in class, “they are able to mention the local units like the Milk tins and the Milo tins, and others…” Also students are able to tell that those measurement are non-uniform, because of cheating, “you will see that they [students] would come out with the information that some hit the bottom part of the container, so when you buy with the same margarine container, the results would be different.” (TC) She also said that students make use of out-of-school cultural notions in fractions in school, but the problem arises especially when the students are aware of differences in their ages:

> yes they use, but the problem arise if they know I am the eldest, I should take the bigger part, so when it comes to sharing equally between an elderly person and a younger person then the application [of fractions] doesn’t hold. (TC)

This point was evident in the interviews with grade four students. Findings from interviews with TC also showed TC as saying students' skills in oral computation do not translate into written computation, when they are working sums, "At home they know that if I take five hundred cedis to buy three hundred of something I would be getting two hundred, but to write it down and subtract at times it becomes a bit difficult for them." (TC)

Findings from the interviews with the headteacher of School C (HC) showed HC as also saying teachers make use of OOSM in measurement, "like for instance in measurement a group of children are asked to find out what their parents use in measuring things, is it "Olonka" or what?, another group margarine 'chence' [local name for a tin] another group 'rubber' [usually equal two 'Olonka'] and so on." HC perceived OOSM as enhancing the introduction of lesson, and making the lesson delivery lively:

> the kids, most of them sell after school so they know this kind of measurement, the addition they know, subtraction and what have you. So having this in mind when they come to school they are already aware because they sell, they are aware of addition, subtraction, multiplication; the four main operations... they have heard of "Fa ka ho," that is addition, "tsiw fir mu," that is subtraction, they are aware of these, so it is like when they come, it is used as their RPK [Relevant Previous Knowledge], which enhances introduction of the lesson, and it makes the lesson very lively and understanding. (HC)

6.1.5 Cultural Differences Students Bring Up in Mathematics Lessons

According to Teacher C (TC), the cultural differences children usually bring forward in lesson on fractions involves unequal sharing, "... the problem arise if they know I am the eldest I should take the bigger part." TC identified comparing fraction as being difficult for children, and perceived children's problem with identification of fractions as being a cultural interference, "yes it interferes their learning, when comparing the fractions that is where the problem comes ...” According to TC, “when teaching measurement, they [students] are able to mention the local units, like the milk tins, and the Milo tins, and others...” However, TC handles culture difference by using the school knowledge to help the students:

> … we don’t consider you as the eldest or whatever, but equity, we want to share it equally, especially taking the class, we are all in this class, say six or four, so we share it equally; that is how I solve the problem. (TC)

TC concentrates on the school’s way of doing mathematics because she has to follow what the syllabus says, “that is what the syllabus that has been provided for us to follow says.” TC believes if students bring forward OOSM in ISM, she has to teach them what the syllabus says, “... they [children] know the home one, so if they bring it up, you teach them what the syllabus says or what has been prepared to be followed.” (TC)

Analysis of TC’s marking of students’ worksheets, from interviews in school confirms she rejects the use of OOSM in school, once it is not in agreement with what the syllabus says. In sharing ten and half margarine cups of maize amongst three grade 4 students, the students shared it according to their ages. The eldest (15years) had four cups and the other two, who were 10 years each had three cups (see Section 6.1.1.6 above). The remaining half cup was put aside. Their Teacher (TC) rejected their approach, as shown in Figure 6.1.17.

Results from document analysis also indicated that TC rejects non algorithmic approach to mathematics problem solving. This was evident in her marking of students’ response to an activity, which required them to multiply 6.5 by 3 (see Figure 6.1.17).

Teacher C’s marking of 10.5 divided by three

We use margerine to share it when we share it one person get four and two peoples get three it remean $\frac{1}{2}$

Teacher C’s marking of 6.5 times three

$6+6=12+6=18+1=19+\frac{1}{2}=19\frac{1}{2}$

$\frac{1}{2}+\frac{1}{2}=1$

Even though the answer is correct the approach is wrong.

Task V

Figure 6.1.17. Teacher C’s marking of students’ activities in school.

Interviews with the headteacher of School C showed HC as saying students usually bring forward culture differences during lessons in measurement, “... they just know measurement but the unit to assign i.e. is it in cm, is it in metres? They don’t know that; all that they know is measurement.” According to HC, teachers concentrate on the school’s way of doing measuring, by taking students through terms in measurement, before introducing them to actual measurement, “the teachers take them through the units of measurement that is units assigned. We normally take them through cm, metres, mm, kg and what have you. We take them through those terms used, before we introduce the actual measurement.” HC thinks teachers handle culture differences in measuring by concentrating on SI units, because that is what the policy says:

> the policy [syllabus] states that they should measure by assigning units to it. It is in the objectives; it is stated clearly/emphatically that kids should know the common SI units. That is why teachers normally take them through, so it is the policy that teachers are to go through [the SI units] with the kids. (HC)

6.1.6 Parents' and Teachers' Collaboration in Students' Mathematics Learning in School

According to Teacher C (TC), she collaborates with parents mainly through, "inviting the parents, and talking to them about child's performance, and then suggesting solutions for parents ..." The findings from the interviews indicated that collaboration between TC and parents becomes necessary when a student is observed to be very weak in the subject:

> there are some of the children who are very weak in the subject, so if such a pupil is observed then the parents would be invited to talk to, so that they would see to the child at home, to do any assignment or to learn at home. (TC)

Interviews with HC revealed that the school usually encourages parents'/teacher collaboration, "sometimes we organise meetings between the parents of the kids and the teachers." According to HC these meetings become necessary "...when we realise that the concept stated in mathematics syllabus is different from what the children give us; so it is then that we say that we should rely on the parents." (HC)

6.1.7 Summary of Findings from School C

In Section 6.1 findings from students' activities, as well as interviews with grade four and six teacher, and headteacher of School C, were presented. The results from students' activities (both at home and school) on fractions showed that students had difficulty identifying fractions, especially in the real life situation. Students used the same fraction name to describe different fractions in the activities at home and in school. The findings also brought to light that students' notion of unit fractions was not fixed.

Although students were able to identify a half in the real life problem, they appeared to have difficulty identifying the same fraction in the paper and pencil activity. The most common fraction names that were often used by students throughout the activities involving the identification of fractions in real life situation were a quarter and a half. Grade four students did not think of sharing as involving equal sharing. The students' notion of part whole relationship in fractions in school appeared to be limited to the number of shaded portion(s) divided by the number of partitions in the whole, instead of the relationship between the shaded portion of the whole and the whole.

The students approached measurement in an informal manner, using the local unit of measure [an empty margarine cup] in all contexts. Division was approached as repeated subtraction; multiplication was approached as repeated addition whilst addition of mixed numbers was done using the decomposition method in the problem solving. In measuring using local activities grade four students rounded their measurement. Grade six students were able to find an area of a rectangle in the local activity but not paper and pencil activity. English was a barrier to students' understanding of word problem solving.

Informal approach of verbalising answers followed by oral and written presentations was used by students throughout the activities. Students often used mathematical equations to support solutions to problems they solved in the in-school task, as compared to the out-of-school task.

The findings concerning students' perceptions about mathematics indicated that both sets of students had culture-related perceptions about mathematics. Students' schema of persons who use 'mathematics' included "a local market woman selling rice" "a farmer" and "a Kente/Twil weaver". They, however, perceived OOSM and ISM as being different. They related ISM to the educated and OOSM to farmers and traders. ISM was more important to students than OOSM. Though students' appreciated the importance of their parents' mathematical practices, they perceived it as being different from school mathematics. They generally devalued their parents' mathematical practices.

All participants said that the English language is mainly used in the school. However, the majority (7 out of 8) of the students said they use Fante in communicating with their parents and friends at home. Despite the difficulty the students had reading the word problem, the majority (7 out of 8) of both grades four and six students preferred the use of English as a medium of instruction. Only one grade four student preferred the use of the local language as a medium of instruction. Their teacher (Teacher C) also preferred the use of English language as a medium of instruction, she also preferred her students to use English during mathematics lessons, whilst the headteacher of the school preferred the use of both English language and local language as the medium of instruction.

The findings regarding students' thinking language showed that majority (6 out of 8) of the students said they thought in Fante, only SC64 and SC42 said they thought in English.

The responses from the headteacher and TC indicate that teachers make use of OOSM in ISM. However, both of them perceived the Ghanaian school language policy as affecting the use of OOSM in ISM. They also indicated that students bring forward cultural differences in mathematics lessons. However, analysis of documents and interviews showed that Teacher C rejects cultural differences (that are perceived not to support ISM). The findings also showed that teachers concentrate on the school mathematics even if students bring forward cultural differences.

Finally the findings concerning parents' and teachers' collaboration in students' mathematics transition indicated that parents' and teachers' collaboration in students' mathematics transitions becomes necessary when students perform poorly in ISM. The findings also indicate that collaboration between parents' and teachers' is mainly in the form of the teacher suggesting solutions to parents.

In the next section findings from School L (the school that discourage the use of OOSM in ISM) will be presented. As with School C, the findings from students' activities as well as interviews with the headteacher and teachers on social and cultural influences on students' mathematics learning, as well as students' transition experiences between home and school context will be presented.

6.2 School L

In this section findings in School L will be presented. These involve findings from focus group interviews with 4 grade six and 4 grade four students, and the individual interviews with their teachers (Teacher L6 and Teacher L4), and the school's headteacher (HL). Thus the interview results will be presented in Sections 6.2.1 to 6.2.6.

6.2.1 Children's Activities

In this section, findings concerning how both grade four and six students experienced those four concepts discussed in the introduction of chapter six (see Section 6) at home and in the school contexts will be presented.

6.2.1.1 Students' activities at home: Identifying and comparing fractions.

Out-of-school task: Table 6.2.1 presents findings from students' activities on the identification of one-sixth and one-fifth at home. The findings from Table 6.2.1 show that as with the students from School C, students from School L also had difficulty identifying unit fractions in the out-of-school task. None of both sets of students was able to identify one-sixth and one-fifth in the out of school task. The majority (3 out of 4) of the grade four students used the same fractions name to describe the two fractions.

Table 6.2.1. Identification of one-sixth and one-fifth by students from School L at home

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SL61	one over two	one over three
	SL62	one over two	one whole
	SL63	one over two	one whole
	SL64	one over two	one out of one
Four	SL41	Quarter	Quarter
	SL42	Quarter	half
	SL43	Quarter	Quarter
	SL44	Quarter	Quarter

When the two sets of glasses (A1 and B1) with their contents were presented to the two sets of students (grades six and four) to compare, all of them identified the content of Glass B1 (one-fifth) to be more than Glass A1 (one-sixth).

The findings further indicated that some of the grade four students (SL42) had problems representing unit fractions (see Figure 6.2.1). Presentation of students' answers in Figure 6.2.1 shows that SL42 presented a quarter as 4 out of 1 (four), and a half as 2 out of 1 (two).

Grade four students’ presentation

Glass A1 Glass B1

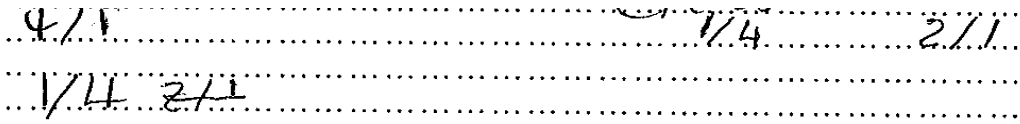


Figure 6.2.1. School L students’ presentation of content of Glasses A1 and B1 at home.

Also presented in Table 6.2.2 are the findings from School L students’ identification of half and three-fifths in the out of school task at home. The findings from Table 6.2.2 show that all grade six and four students were able to identify a glass half full of water, but neither the grade six students nor the grade four students were able to identify a glass three-fifths full of water. All grade four students and half of grade six students used the same fraction name to identify the two sets of fractions.

Table 6.2.2. Identification of half and three-fifths by students from School L at home

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SL61	half	One and half
	SL62	half	half
	SL63	half	quarter
	SL64	half	half
Four	SL41	half	half
	SL42	half	half
	SL43	half	half
	SL44	half	half

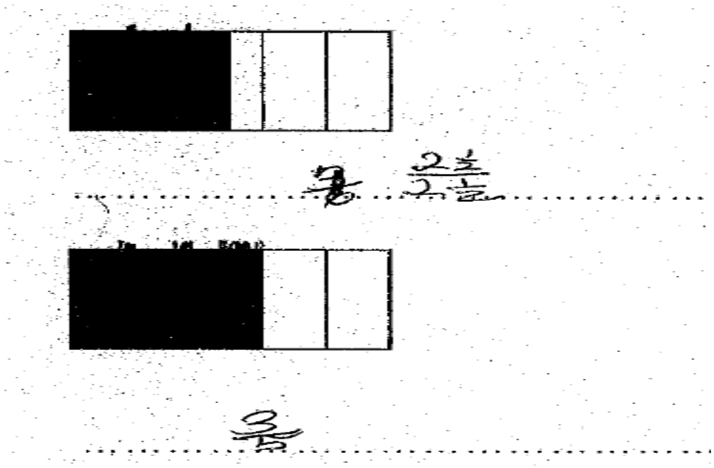
When the contents of the two glasses were presented to both sets of students to compare, one would have expected all grade four students, for example, to say they are equal but all the students (both grade six and four) said the content of Glass B2 was more than Glass A2.

The findings from out-of-school Tasks 1 and II appear to show that students (both grade six and four) notion of a half is not fixed; it could be at the midpoint (all students) or above the midpoint (SL62, SL64 and all grade four students). Students generally had weak conceptions about fractions, especially SL42 and all grade six students. The most common fraction name that was often used by grade six students in the Task I & II was a half (six times), whilst the most common fraction names that were used often by grade four students were a half (nine times) and a quarter (seven times).

In-school task: The findings from the in-school task on fractions at home also showed that both grade six and four students had difficulty identifying fractions. As with the students in School C, they also tended to concentrate on the number of partitions in the whole and the shaded portion(s) to decide on what fractions they were dealing with, rather than looking at the shaded portion(s) in relationship to the whole. For example in identifying one-sixth, they counted six divisions and one shaded portion, and presented their answers as one-six. They were therefore able to identify one-sixth and one-fifth in the in-school Task1, and three-fifths in in-school Task II without problems. They, however, had difficulty identifying half (a fraction they were able to identify in the out-of-school task) in in-school Task II. This was because they could not easily figure out the number of divisions in the whole (see Figure 6.2.3).

SL44 began to present grade four students' solution but SL42 crossed out SL44's representation of one-fifth and went on to present the group's solution wrongly, exchanging the denominator for the numerators (as shown in Figure 6.2.2). Apart from SL44 who occasionally challenged SL42, none of the other group members challenged SL44, because he was the only student participant who often communicated with the researcher in English, and also translated English text into the local language in the group.

Grade six students' presentation



Grade four students' presentation

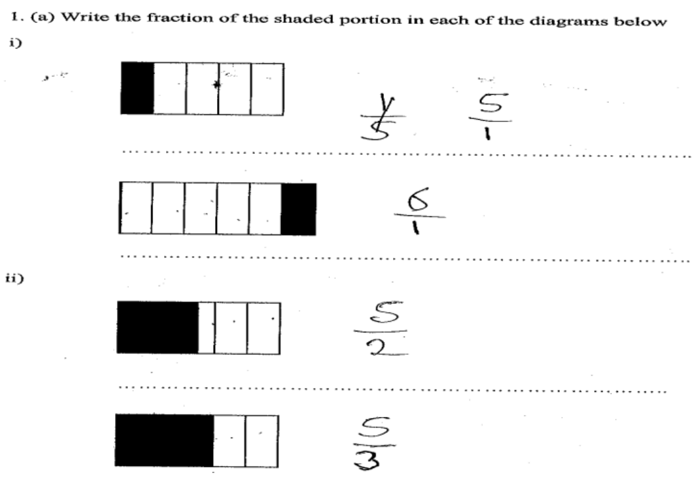
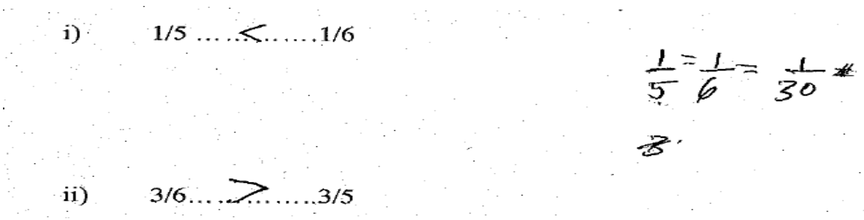


Figure 6.2.2. School L students' presentation on identification of fractions in-school Task II.

Students' inability to identify a half is an indication that their notion of part-whole relationship in fractions in school is also limited to number of shaded portions divided by number of divisions, instead of relationship between the whole and the shaded portion of the whole.

In comparing one-fifth and one-sixth, and three-sixths and three-fifths, unlike students in School C, both grade six and four students in School L used the wrong symbols to compare the two sets of fractions. Whilst the grades six students attempted to employ the concept of least common denominators to justify their wrong answers, grade four students' could not justify their answer at all (see Figure 6.2.3).

Grade six students' presentation



Grade four students' presentation

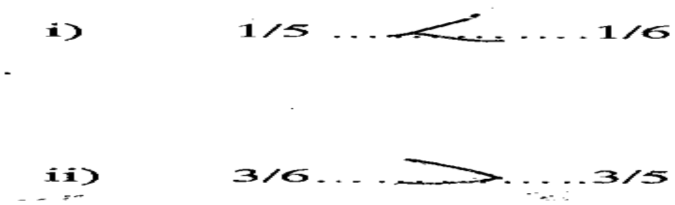


Figure 6.2.3. School L students' presentation on comparing one-fifth and one-sixth.

6.2.1.2 Students' activities at home: Division of fractions/measurement of capacities.

Out-of-school task: Grade six and four students approached the activity differently. Grade six students in School L approached their solution to the task in similar manner (an informal way) as grade six students in School C (see Section 6.1.1.2 above), to arrive at their correct answer of three and half cups. They also requested a margarine cup as a unit of measure, set three containers and went round each of these containers with a cup of maize to find out what each one would get before finding the total number of cups of maize through oral computation. Unlike grade six students in School C, they presented their solution in prose, as shown in Figure 6.2.4.

Unlike the grade six students, grade four students approached the out-of-school task in a formal way. They requested a measuring scale when the task was presented to them. They wrongly read the measurement from the scale (as 4500 grams), after which they verbalised their answer (as 1500, which was correct based on their reading). They however had difficulty justifying their answer. They were not sure which operation sign to use, as shown in the excerpts of the interviews below:

Students: [Put the maize on the measuring scale, all read the scale]

SL42: four thousand five hundred

Students: sir it is 4500grams [chorus]

R: share it among the three children and tell how much each child will get

Students: [discuss for while in Fante....]

SL44: thousand five [orally]

Students: thousand five [chorus]

SL42: [writes thousand five]

R: Explain your solution to me

SL42: [explains in Fante] sir four thousand five hundred gram we gave each child thousand five, thousand five to arrive at the answer….

R: Write down your solution

Students: [Discuss in Fante for a while ...., and present their solution as shown in Figure 6.2.4]

Grade six students' presentation

(c) Write your solution on the worksheet

We use margerain cup to shear the maize and One person shear it and ~~everybody~~ We are four peo-ple but three people shear the maize and everybody $3\frac{1}{2}$

Grade four students' presentation

1500 g

$$\begin{array}{r} 4500\ g \\ \div\cancel{\times}\quad 3 \\ \hline 1500\ g \\ \hline \end{array}$$

Figure 6.2.4. School L students' presentation of 10.5 divided by 3 in out-of-school task at home.

In-school task: As with the out-of-school task, grade six and four students approached the activity differently. Grade six students' used the same informal approached they used in the out-of-school task to solve the in-school task. Thus they requested a margarine cup as a unit of measure, found what each person would get, before finding the total number of cups of rice as ten and a half, through oral computation. As with the out-of-school task (see Figure 6.2.4), they presented their solution in prose. In both the out-of-school and in-school task, grade six students did not provide any written computation; oral computations and prose were used to explain their thinking in their solution to the problem.

The grade four students followed a similar approach they used in the out-of-school task to measure the rice using the measuring scale. They read the weight of the rice as, "eight thousand" (which was wrong). As usual they got confused as to which operation to use to find what each person will get, "shall we make it plus? Let us subtract, everybody will get five, five …." (SL42) They ended up presenting their solution wrongly as 8 times 4 equals 24, and wrote 8 as an answer to what each of the three who shared the rice will get.

6.2.1.3 Students' activities at home: Multiplication of fractions/measurement of capacity.

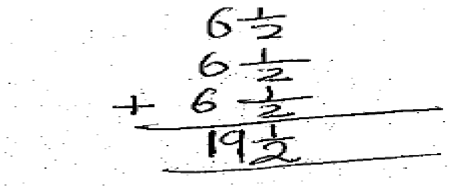
Out-of-school Task: As with the students in school C, both grade six and four students in School L also approached their solution informally, by verbalising their answer, before orally computing and writing down their answers on their worksheets (once they were requested to do so).

Thus in solving 6.5 times three in the out-of-school task by the grade six students, SL63 counted the finger [silently] and called out the answer as, "nineteen and half." They justified their answer through oral computation as, "six and half plus six half … equals nineteen and a half" [chorus]. SL63 presented the group's solution without any mathematical equation as "they get $19\frac{1}{2}$."

When the grade six students were requested to show how they arrived at their answer on the worksheet, like the students in School C, they used a mathematical equation involving repeated addition of six and half to justify their answer as nineteen and half, as shown in Figure 6.2.5.

For the grade four students, SL44 first called out the wrong answer as eighteen. SL42 said, "let us add three sixes together and three halves together; ... that will be nineteen and a half" However, as usual, SL42 went on to presented the group's solution wrongly by adding the numerators and the denominators to get nineteen-thirds, as shown in Figure 6.2.5.

Grade six students' presentation



Grade four students' presentation

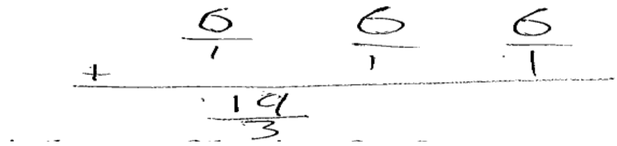


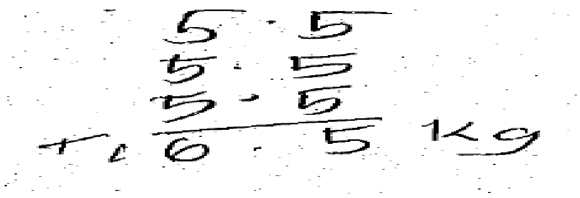
Figure 6.2.5. School L students' explanation of solution to 6.5 times three in out-of-school task at home.

In-school Task: Whilst grade six students solved the word problem solving which involved 5.5kg time three correctly, using repeated addition of 5.5kg plus 5.5kg plus 5.5kg, grade four students had difficulty reading and understanding the question.

Grade six students discussed the question for a while [in Fante], "Ama bought 5.5kg and Esi bought thrice what Ama bought…. so we have to add" (SL63), SL64 wrote the group's solution as repeated addition of five, before orally saying, "it is sixteen and a half." They finally presented their solution as shown in Figure 6.2.6.

Some of the difficult words for the grade four students included "quantity" and "whilst". They read "quantity" as "canteen", so SL42 interpreted the question to mean, "Esi bought three times canteen of rice" (in Fante language) but finally presented their solution as a subtraction sentence (see Figure 6.2.6).

Grade six students’ presentation



Grade four students’ presentation

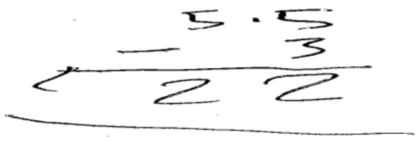


Figure 6.2.6. School L students’ presentation of 5.5 times 3 in out-of-school task at home.

6.2.1.4 Students’ activities at home: Addition of fractions and measurement of area.

Out-of-school task: Using the same approach as grade six students in School C, both grade six and four students in School L were also able to add fractions and measure the area of a rectangle through local activities of measuring using “poles” as unit of measure in this task. Through these activities, students (both grades six and four) were able to add two quarters to arrive at the correct answer as a half. They were also able to measure and find the area of two and a quarter units by two units rectangle correctly as four and a half, but they did not indicate the unit of measure, as was the case in School C (see Figure 6.1.7). SL42, who happened to be a very active member of the group, however, presented grade four students’ solution as four halves.

In-school task: Even though both grade six and four students were able to add quarters in the out-of-school task, grade six students could not subtract unit fractions in the in-school task, whilst grade four students could not add quarters in the in-school task.

Grade six students explained the demands of the question as, “he divided it [the orange] into four and gave Abena 1, and Ekua 2, so how many oranges were left?” (SL64) Thus they interpreted the question as involving subtraction, instead of addition. They presented their solution in a diagram, without any written explanation (see Figure 6.2.7).

Grade four students read the question with some amount of difficulty. The difficult words were “gave”, “much” and “did”. They interpreted the demands of the question as “Papa Kojo gave Abena one over four of an orange and Ekua too one over half of an orange” (SL42), after which SL44 verbalised the answer as “three-eighths”, and presented the group’s solution as shown in Figure 6.2.7.

Grade six students’ presentation

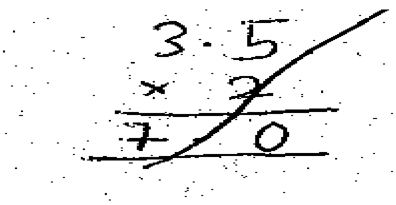
Grade four students’ presentation

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{8}$$

Figure 6.2.7. School L students’ presentation on the solution to two-quarters minus a quarter.

Also, even though students were able to solve problem involving the area of a rectangle in the out-of-school task, Grade six students had difficulty in solving similar problem in the in-school task. In solving the in-school task which involved finding the area of 2cm by 3.5cm rectangle, SL63 presented the group’s solution as 3.5 times 2 equal seven. The others disagreed; SL64 crossed out SL63’s presentation and rather added 3.5 to 2 to get 3.7cm as shown in Figure 6.2.8.

SL63's presentation



SL64's presentation

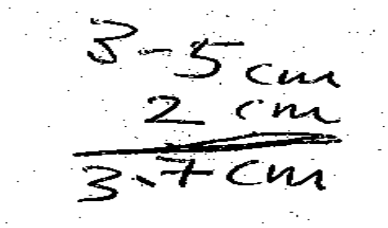


Figure 6.2.8. School L students' presentation of solution to the area of 2cm by 3.5cm rectangle at home.

It can be observed that no mathematical equation was provided in the case of measurement of area in out-of-school Task V. Also, their approach to in the in-school task showed clearly that they did not attach meaning to what they were doing (as will also be seen in Section 6.2.8).

In Sections 6.2.1.5 to 6.2.1.8 the result of students' activities in school will be presented. The tasks students went through in school were the same task they were given at home (see Appendix G01, Part II and Appendix G02, Part II). Thus students' activities in school also covered four areas, namely identifying and comparing fractions, division of fractions/measurement of capacities, multiplication of fractions/measurement of capacity, and addition of fractions and measurement of area (see Section 6). Findings from students' activities in school are presented below based on these four areas.

6.2.1.5 Students' activities in School: Identifying, and comparing fractions.

Out-of-school task: A summary of the findings from students' activities on identification of a glass one-sixth full of water and a glass one-fifth full of water is provided in Table 6.2.3. Findings from Table 6.2.3 show that both grade six and four students' had difficulty identifying unit fractions in the out-of-school task in school.

None of them was able to identify one-sixth and one-fifth in Task I. SL64 identified the content of Glass A1 as “half quarter” and explained it as “half of a quarter”. This shows the difficulty some of the students had naming unit fractions in the real life situation. It is also evident from Table 6.2.3 that as with the activities at home (see Table 6.2.2), all grade four students used the same fraction name to identify the two fractions, whilst half of grade six students also did the same. As usual, SL42 continued to write fractions the same way he did in the out of school task, exchanging numerators for the denominator (see Figure 6.2.1 above).

Table 6.2.3. Identification of one-sixth and one-fifth by students from School L in school

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SL61	quarter	quarter
	SL62	quarter	quarter
	SL63	half	quarter
	SL64	Half quarter	No response (silent)
Four	SL41	quarter	quarter
	SL42	quarter	quarter
	SL43	quarter	quarter
	SL44	quarter	quarter

Both sets of students identified the content of Glass B1 (one-fifth) to be more than Glass A1 (one-sixth), when they were requested to compare the contents of glasses A1 and B1.

Table 6.2.4 presents findings from identification of a glass half full of water and a glass three-fifths full of water in Task II, in school. The findings in Table 6.2.4 show that all grade six and four students were able to identify a half but neither the grade six students nor the grade four students were able to identify three-fifths. Also half of grade six students used the same fraction name to identify the two sets of fractions.

Table 6.2.4. Identification of half and three-fifths by students from School L in school

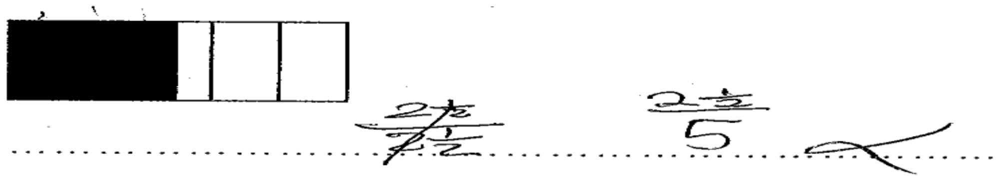
Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SL61	half	One one-quarter
	SL62	half	quarter
	SL63	half	half
	SL64	half	half
Four	SL41	half	One and a half
	SL42	half	Four over three
	SL43	half	No response
	SL44	half	No response

Comparing the contents of the two glasses, all of both sets of students identified the content of Glass B2 (three-fifths) to be more than Glass A2 (half). The most common fraction names that were often used by both sets of students were a quarter and a half.

In-school-task: Both grade four and six students approached the task using the same approach they used in the activity at home (see Section 6.2.1.1) They concentrated on the number of partitions in the whole and the shaded portion to decide on what fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole. Both sets of students were therefore able to correctly identify one-sixth and one-fifth in the in-school Task1.

In Task II also both sets of students were able to identify three-fifths. However, unlike the activities at home the grade six students rather identified a half as two and half out of five, whilst grade four students identified it as also as three-fifths. Thus like the out of school task, grade four students used the same fraction name to describe the different fractions (see Figure 6.2.9).

Grade six students' presentation



Grade four students' presentation

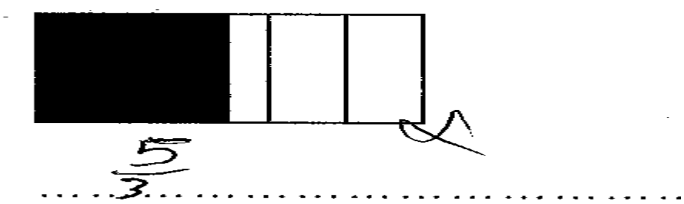


Figure 6.2.9. School L students' presentation on identification fractions in-school Task II in school.

This confirms the earlier observation that students' notion of part-whole relationship in fractions seems to be limited to number of shaded portions divided by number of divisions, instead of relationship between the whole and the shaded portion of the whole (see Section 6.2.1.1).

Whilst grade six students were able to compare one-fifth and one-sixth, and three-sixths and three-fifths correctly, using "greater than" or "less than", grade four students had it wrong (as with the activities at home). Thus in comparing the two sets of fractions grade six students used the correct symbols to compare all fractions and justified their answers correctly using the concept of least common denominator, "the LCM[Least Common Multiple] of six and five is…thirty" (SL63); "five goes into thirty?"(SL64) Grade four students approached it the same way they did in the activity at home (see Figure 6.2.3).

6.2.1.6 Students' activities in School: Division of fractions/measurement of capacities.

Out-of-school Task: As with the activities at home, grade six and four students approached the activity differently. Grade six students used the same (informal) approach they used in the activities at home (see Section 6.2.1.2). They requested a margarine cup as a unit of measure, found what each person would get (which was three and a half cups), before they finally found the total number of cups of maize as ten and a half cups through oral computation. They presented their answer in meaningless prose as, "we use margarine [sic] cup shear [sic] the maize and three people shear maize and everybody get $3\frac{1}{2}$."

Grade four students approached this activity in a similar manner they did at home to arrive at same answer they had at home (Section 6.2.1.2). As with the out of school activities at home, they requested a measuring scale once they were presented with the maize to share among three people. They had difficulty reading the weight of the maize from the scale. As with the activity at home, they also had difficulty deciding which mathematical operation to use to share the maize among the three people, as shown in the excerpts from the interviews below:

Students: [read the scale]

SL41: it is 4000

SL42: it is 4000 and a little more

SL44: [writes down 4000g]

R: Alright! Share it among the three people and write your solution

SL41: let us make it plus

SL42: let us make it times; I am not sure whether it should be plus or times, SL44 what do you think?"

SL44: Plus

SL41: Subtract

SL42: let us give each of them thousand two and see what happens

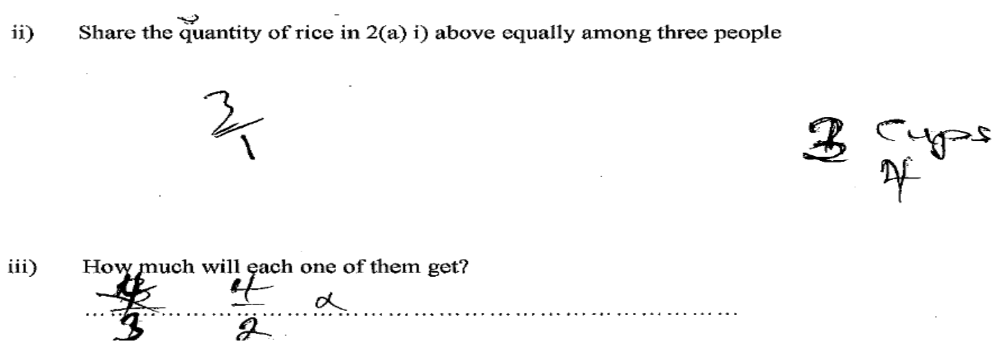
SL44: let us give each of them 1500 [he presented the group's solution similar to their solution in Figure 6.2.4]

In-school Task: Unlike the out-of-school task, both Grade six and four students approached their solution in an informal way, using margarine cups as a unit of measure. However, they approached their solution differently. Grade six students approached it the same way as the out-of-school task. Thus they found what each would get by going round each of the three containers with a margarine cup of rice, and found the total number of cups of rice through oral computation. Again, they presented their solution in prose as, "we use margrine [sic] cup to shear [sic] the rice so everybody get $3\frac{1}{2}$."

Grade four students used an empty margarine tin instead of measuring scale in this activity because, "when we use it we shall see the answer easily" (SL43); "we will see the answer faster than the scale" (SL42). Unlike the grade six students, they measured all the maize into a bowl. All except SL42 said the total was ten and a half cups. SL42 said, "it is ten and quarter cups."

When they were requested to share the rice among three people, as usual SL42 picked the margarine cup, with the help of other group members, he measured three cups into a container, they compared what had been measured into the container with what was left and said, "each of them will get four and half cups." As usual, SL42 who appeared to have dominated the activity at this stage presented the group's solution as shown in Figure 6.1.10.

Grade four students' presentation


ii) Share the quantity of rice in 2(a) i) above equally among three people

iii) How much will each one of them get?

Figure 6.2.10. School L students' presentation of 10.5 divided by three in in-school task in school.

6.2.1.7 Students' activities in School: Multiplication of fractions/measurement of capacity.

Out-of-school Task: As with the out-of- school task at home, both sets of students approached their solution to the problem as a repeated addition. Grade six students used the informal approach of verbalising their answer as "nineteen and a half" (SL63), and orally explaining their solution as, "we have to add three six and halves" (SL64); "... three people share nineteen and half each will get six and a half, …" (SL63) They provided a written presentation of their solution (once they were requested to do so) as a repeated addition of six and halves.

Grade four students had difficulty solving the problem involving 6.5 times 3. Unlike the activity at home (see Section 6.2.1.3), they added the numerators and the denominators of the fractions together "we must add …" (SL44). As usual, SL42 presented the group's solution as shown in Figure 6.2.11 to arrive at 27 as their final answer.

Grade four students' presentation

$$\frac{6}{3} + \frac{6}{3} + \frac{6}{3} = \underline{27}$$

Figure 6.2.11. School L students' presentation of 6.5 times three in out-of-school task in school.

In-school Task: Both sets of students were able to solve the word problem involving 5.5kg times three. Grade six students approached the task using a similar informal approach as in the activities at home (see Section 6.2.1.3). SL63 verbalised their answer as, "sixteen and a half". As with the out-of-school task in school, they provided their written solution as a repeated addition of 5.5 thrice, using mathematical equation to arrive at their correct answer of 16.5kg.

As with the activities at home, grade four students had difficulty reading the word problem. They could not figure out the demands of the question, so they could not attempt the question [remained silent]. However, when the researcher wrote "5.5kg x3" on a sheet of paper for them to solve, as with the grade four students in School C (see Figure 6.1.13), they were able to solve that without problems.

6.2.1.8 Students' activities in School: Addition of fractions and measurement of area.

Out-of-school task: As with their activities at home (see Section 6.2.1.4), grade six students were able to add fractions and measure the area of a rectangle, through the traditional activities of measuring using "poles" as unit of measure. Through these activities they were able to add two quarters to arrive at the correct answer as half. They were also able to find the area of two and a quarter unit by two unit rectangle correctly, as four and half "poles".

However, grade four students measured four “poles” and guessed the remaining portion. They got divided as to what the remaining part should be. SL41 and SL43 said it was four and half because, “when we measured some was left, so it is half…” (SL43). SL42 and SL44 said it was four and a quarter because, “when we measured it was left with a little and that cannot be a half.” (SL44)

In-school task: Only the grade six students were able to solve the word problem correctly. SL63 interpreted the question in Fante correctly as, “quarter and two over four when you put them together…”, after a chorus reading of the question by the group. SL63 verbalised their answer as “... three over eight; two plus one and four plus four.” However, they disagreed with SL63’s presentation; SL64 crossed it out and finally presented the group’s solution correctly as three-quarters.

Grade four students interpret the demands of the question correctly as involving addition, “the question wants us to put what was given to Abena and Ekua together…” (SL42). However, they had difficulty solving the problem. SL44 presented their final answer as five-sixths. The group disagreed with SL42’s presentation so SL43 went ahead to present the group’s solution by adding the numerators and the denominators of the two fractions to get three-eighths.

Grade four students’ presentation

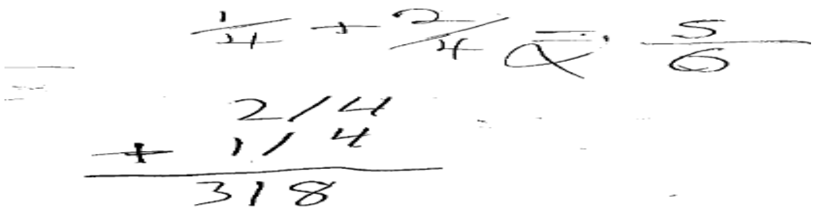


Figure 6.2.12. School L students’ presentation of answer to a quarter plus two quarters in in-school task in school.

Grade six students approached the area of 3.5cm by 2cm rectangle by adding the sides of the rectangle (as in perimeter). They later cancelled their solution and multiplied 3.5cm by 2cm to arrive at the correct answer as seven. However, interviews with children revealed that they knew the answer but they did not know how to work towards the answer, as shown in the excerpts from the interviews below:

> **R**: Why did you multiply?
>
> **SL63:** when we used plus we could not get the answer but times worked, because two times three worked and two times five also worked

For both the out-of-school and in-school Tasks at home and in school, both grade six and four students used the local language in communicating amongst themselves. They used the same language mainly in communicating with the researcher. All grade six students said they used Fante in thinking, as they went through the activities at home but in school SL63 and SL64 said they thought in English. The situation was different in grade four; SL41 and SL43 said they thought in Fante, whilst SL42 and SL44 said they though in English, as they went through the activities at home, “I use English in thinking.” (SL42) but in school, interestingly, all of them said they thought in Fante. This was evident in their solution to word problem. They read the question in English, discussed it in Fante and presented their solution on the worksheet in English.

6.2.2 Students’ Perceptions

6.2.2.1 Students’ perceptions about mathematics

As with the grade six and four students from School C, interviews with students in School L also showed that they had culture-related perceptions about mathematics. Both grade four and six students identified “a local market woman selling rice”, “a driver’s mate”, “a farmer” and “a Kente/twil weaver” as people who use mathematics.

Grade six students however perceived OOSM and ISM as different, “they don’t look alike” (SL62). ISM was more important to all students because, “if teachers don’t teach us one over two, or two or four, we will not know it.”(SL63) Students associated OOSM with women, “it is good for women, because they sell” (SL63), whilst ISM was associated with men because, “if you do not go to school, and you do not get a good job, and you marry, you cannot take care of your wife.” (SL64)

All grade four students also valued ISM more than OOSM, “school mathematics is important” (SL41); “if we don’t learn school mathematics we cannot calculate well” (SL43); “if you don’t go to school ...you will not understand maths well” (SL42). They associated OOSM with traders, farmers, and fishermen, whilst they associated ISM with, “bankers” (SL42) “students” (SL44), and “office workers” (SL43). Interestingly, whilst SL41 (a higher achiever) (see Appendix P, Table P02) said, “I understand home mathematics more than school mathematics,” SL42 (a lower achiever) said, “I understand both.” (SL42)

6.2.2.2 Students’ perceptions about parents’ knowledge.

Findings from interviews with students indicated that the two sets of students appeared to perceive parents’ knowledge differently. The Grade six students appeared to value their parents’ mathematical knowledge. Some of the typical explanation they gave included, “how they solve it [mathematics] is not the same as school, but the answer they get is good” (SL63); “it [parents’ knowledge] doesn’t look like the school but it is correct” (SL64).

Interviews with grade four students also showed all of them as saying their parents’ mathematical practices are different from what they experience in school. They rather appeared to devalue their parents’ mathematical practices, “their mathematics is not good, they know mathematics for selling” (SL44), “old fashioned mathematics is what they know” (SL41); “at times they don’t calculate well” (SL42).

6.2.3 Language Use and Preference

6.2.3.1 Students' language use and preference.

Interviews with both grade six and four students showed that English appears to be the language for the classroom. All of them said they use Fante in communicating with their parents and friends at home. However, in school the two sets of students' language use differed. Grade six students said they use English in class whether or not there is a lesson. All of them said they use English in communicating with the teacher during break time. SL64 and SL63 said they use English in communicating with friends when there is no lesson, whilst SL61 and SL62 said they use Fante, "sir Fante" (SL61). All of them said they use Fante in communicating with friends during break time. They said they have to use English with the teacher because, "in class five we had to pay 500 Cedis [40 cent] for speaking Fante" (SL63).

The findings showed all grade four students as saying they use English in class when there is a lesson. They said in chorus, "we use English with teachers and Fante with friends" in class when there is no lesson. All of them said they use Fante in communicating with both the teacher and their friends during break time. Interviews with students also revealed both grade four and six students as saying their teacher uses English in teaching mathematics generally, and fractions and measurement specifically.

The findings concerning students' preferred language showed all grade six students as saying they preferred to study mathematics generally in English, and concepts of fractions and measurement specifically also in English language because, "teacher is not fluent in Fante" (SL63).

The majority (3out 4) of grade four students said they preferred to learn mathematics generally in English because, "we want to speak English" (SL42); "to be able to speak English well." (SL44) SL41 prefers Fante because, "I want to understand the lesson." The majority (3 out of 4) of them preferred to study fractions in Fante, "for everybody to understand.” (SL42) Only SL44 preferred to study fractions in English, “to enable me to speak English.” All students preferred to study measurement in Fante, “to enable us to understand.” (SL43)

6.2.3.2 Teachers’ language use and preference.

Interviews with the teachers in School L (TL6 and TL4) showed both as saying students use both Fante and English in class when there is mathematics lesson, “they use a mixture of Fante and English...” (TL6), “they use Fante and sometimes the two but the majority of them use Fante” (TL4). However, according to the teachers when there is no lesson students use Fante, “Fante, because the children are not good, just a handful of them can express themselves in English,” (TL6) “it is only a few of them who use English, majority of them use Fante.”(TL4) According to TL6 and TL4 students use mainly the local language outside classroom during break time, “they use Fante, … I even tell them that anybody who speaks Fante he/she would pay five hundred Cedis, just to put fear in them but they speak it” (TL6). “...majority of them use Fante only, a few of them use English.” (TL4)

Interviews with the teachers also showed both teachers as saying they speak English with students in class whether or not there are lessons. English is the language they use in teaching mathematics generally, and fractions and measurement specifically. They use English when there is lesson because, “all topics have been written in English ...” (TL6), “that is the medium of instruction in the classroom.” (TL4) They use English when there is no lesson because, “I want them to pick the culture of using English in the classroom, and even the environment in which they find themselves” (TL6), “that is the one I use in teaching them in the class so that is the one I use in communicating with them.” (TL4)

Both of them also said they use English with students during break time because, “… we want them to pick the culture of speaking the language, so break time I speak English language with them, so that they would also practice how to speak the English language,” (TL6) “we are trying to let the children come out with some little,

little English, by so doing they also pick up.” (TL4) However, according to TL6 a few of them understand English, “just a few would be able to understand, when I speak English to them.” TL6 further explained, “even when I speak English to them, they tend to speak Fante to me because some of them cannot express themselves in the English language.”

The results further revealed teachers as saying they mainly use Fante in communicating with students when they meet them outside the school premises, “most of the times when I meet them outside the school premises I use Fante, sometimes too I use English, depending on the person I am talking to.” (TL4)

Both teachers would prefer students to use English language in mathematics lessons because, “… word problem solving is always being written in English language, so if a child cannot express him/herself in English language, I don’t think the person would be able to work, or calculate, or understand the mathematics,” (TL6) “the mathematics is written in English, if they are able to read or speak the [English] language, I think they can understand the mathematics...” (TL4).

However, they appeared to differ in their language preference for mathematics; TL6 prefers to use, “both English and Fante, because not all the children can express themselves in English language ... half of the class cannot speak the [English] language,” TL6 would prefer to use both Fante and English to teach fractions and measurement because of same reason (i.e. difficulty in understanding lessons in only English). However, TL4 prefers to use the local language [Fante] to teach mathematics generally because, “that would make the children understand better, because of their level ... and the community in which they find themselves”. TL4 would prefer to use Fante in teaching fractions, “because that one they would understand better,” but TL4 would prefer to use English in teaching measurement because, “I don’t think it is anything difficult that when I use English they would not understand...”

6.2.3.3 Headteacher's language use and preference.

According to the headteacher of School L (HL), teachers use, "English language mostly in the upper primary, but in the lower primary they tend to use the local language when the children find it difficult to grasp what the teacher is teaching in the class." The results revealed HL as also saying when there is no lesson, "normally they [students] use the local language but some also use English language." According to HL, "when there is no teacher around they tend to use the local language, they feel that would make them happy."

The findings also showed HL as saying students mainly use the local language during break time, "normally most of them use the local language." Unlike the TL6 and TL4, HL prefers teachers to use English in teaching mathematics for two reasons. Firstly, "children are very familiar with the local language," and secondly, "English is what we want them to use in the teaching so children have to use the English."

6.2.4 The Use of OOSM in ISM

6.2.4.1 Policy influences

Interviews with Teachers L6 and L4 (TL6 and TL4) indicated that whilst TL6 appeared to be aware of the language policy of Ghana, which requires the use of Ghanaian language at the lower primary and English language from the upper primary, TL4 appeared not to be aware. "That is English throughout from class four to class six; it is solely English language and L1 [Fante] from primary 1-3" (TL6), "It should be English at the upper class, from P4 up to P6 upwards, the lower primary I think it is the mother tongue and English." (TL4)

Both TL6 and TL4 said the language policy affects the use of OOSM in ISM:

> it affects it because the mathematical ideas in teaching in outside the school is in Fante throughout, so if you bring it to the classroom

> sometimes you find it difficult to translate it to English, that makes it difficult for the pupils to understand, yeah. (TL4)

Interviews with headteacher of School L (HL) indicated that as with TL4, HL was aware of the language policy of Ghana only from upper primary level, but not at the lower primary level, “we are allowed to use the local language and the English together in the lower primary classes 1-3, but from classes four to JHS we are supposed to use the English language.” HL does not think the language policy affects the use of OOSM in ISM, “well I don’t think it has any effect, because the Ghana Education Service have that policy that when the children are having difficulty we have to use both at the lower primary.”

6.2.4.2 Classroom practices

Interviews with Teachers L6 and L4 (TL6 and TL4) showed both of them as saying they use OOSM in ISM, “… I bring the house everyday activities like sorting out things...”(TL6), “I use that as an example for children, it helps them to understand what I am trying to tell them...”(TL4) Both of them said they make use of children’s experience in sharing, “they also share things in their house; they have the idea of sharing. When I am teaching fractions we share ... we use the idea on that” (TL6), “in home you and your brother may share an orange, it comes in there when you are teaching fractions...” (TL4)

TL6 does not employ the out-of-school way of sharing in classroom, “no, because ... we have to show working, so it is different from the house share” TL6 does not believe sharing in out-of-school context support sharing in school, “no, that is [out-of-school notion of sharing] also one thing altogether” (TL6). TL4, however, believes, “it [out-of-school notion of sharing] supports their [students] learning in fraction.” However, TL4 does not generally employ indigenous mathematical ideas from out-of-school setting in his lessons, “no, I don’t make use of indigenous ideas.” This is because, “we are doing mathematics and some of these indigenous ideas go with TLM [Teaching Learning Materials], and so using them is very difficult, so me

I don’t use them.” (TL4) Whilst TL6 was not sure of how students make use of their OOSM in measurement, “as for measurement we haven’t got there..., now we are on fraction.” TL4 said students make use of their out-of-school experiences in measurement:

> when I am teaching litres I ask the children to bring bottles to the school, small size and big size ..., we try that one by asking children to bring those things to the classroom, we also use bowls, and ask them to measure. (TL4)

Interviews with headteacher of School L (HL) showed HL as saying teachers sometimes refer to the home:

> sometimes when they are teaching mathematics they try to refer to what the children have learnt in the house. The children themselves usually talk about it during their mathematics lessons, and some of these children have been selling in the home so they are already aware...

HL perceived OOSM as helping students’ mathematics learning in school:

> Well, even before the child gets to the school, they are aware of so many things in the home. For example, there are so many things that take place in the home that make children aware of measurement. For example, a child knows that when four pupils are sharing an orange we divide it into four ... so they are aware of division, and then they come to the school and use the same process, it means what they have learnt in the house is still helping them in the classroom as well.

However, like the students, HL also appeared to associate OOSM with the illiterates, “our parents who have not been to school before these are the things that help them to sell in the market...”

6.2.5 Cultural Differences Students Bring Up in Mathematics Lessons

According to Teacher L6 (TL6), the cultural difference children usually bring forward in mathematics lesson relates to oral computation:

> in the home parents do not teach them actual mathematics, it is oral work, but when you come to the school classroom work it is always written lesson; so children would have to solve things mathematically, not saying it orally. They are supposed to work and work, and by so doing know how the calculation of certain problems is [sic] done, but not saying it orally; so that is different from the home.

According to Teacher L4 (TL4):

> sometimes some of them come with counters in their bags. I have seen some of them using it, and they write their answer in the book. Some come even with sticks grouped in tens or fives and hide them in their bags, and bring them to the classroom, and they use them in the classroom in P4 [grade four].

According to TL6, he handles cultural difference by trying to develop what children already know, "if I am teaching a topic and I see that they have the background knowledge on the topic, I tend to use what they already know." TL4 however prevents the use of counters in his mathematics class, "when I see them using those things I normally don't agree; I seize them, I want them to use their own this thing [pointing at his head]." TL4 prohibits the use of counters because, "I think at that level they shouldn't be using those things in doing mathematics..."

Analysis of TL6's marking of students' worksheet showed that he rather appeared to reject the use of OOSM in ISM. This was evident in TL6 outright rejection of students' method, which involved the use of empty margarine cup as a unit of measure, and the use of prose in their solution, as shown in Figure 6.2.13.

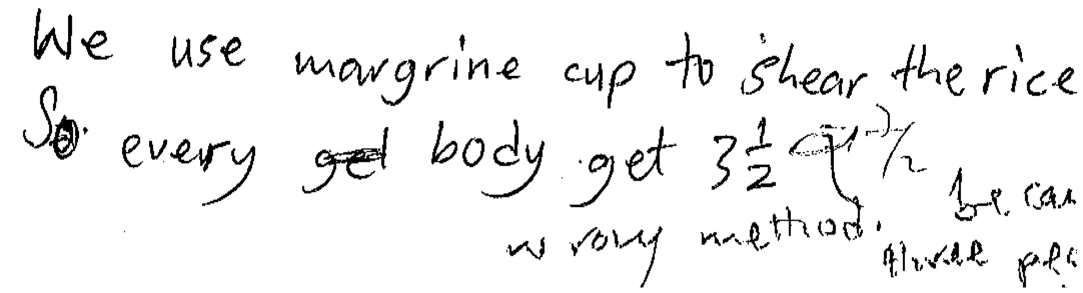


Figure 6.2.13. TL6's marking of students activities on 10.5 divided by 3.

Interviews with the headteacher of School L (HL) showed HL as saying students usually bring cultural differences during mathematics lessons, "well, sometimes when the teachers are teaching, children tend to bring the ideas they have in the home; for example counting of fingers, they do it in the house, so they tend to bring them." HL explained further, "for example when they are in difficulty they tend to count their fingers..." According to HL, the school discourages finger counting, "we are not encouraging it ... because if we don't do it they will carry it to the higher [grade] levels."

6.2.6 Parents' and Teachers' Collaboration in Students' Mathematics Learning in School

Interviews with the teachers (L6 and L4) showed TL6 as saying he does not collaborate with parents:

> emm! actually I don't collaborate with them, but I normally tell the parents to help them [students] to learn mathematics and English and all the subjects, so when I give the child homework to do, as a parent you make sure the child study. But in this community they don't even come to the school to inspect pupils' work, they don't pay us visit, they don't find out whether the children are performing well or badly. They don't care; after closing you see the child going to sell. Even I came here one

evening, I saw a lot of children in the street whilst their books are asleep [sic] they are not asleep, so such a community like that, they are not helping the teachers, so when it comes to collaboration with parents I think I will be wasting my time ...

TL6 does not collaborate with parents because:

> the parents are not helping us. They don’t come, I will never go to their house because the children are many, it is a waste of time, but if they come, then I will collaborate with them. Then I will give you advice on how best to help your child/ward to learn mathematics, but if you are not coming I cannot go to the parents, they are many, and nobody will pay me for that. When they come to the school I have every right to collaborate with the parents, but if they are not coming how am I going to collaborate with them?

TL4 said he rather collaborate with a few, who visit the school:

> only few parents do visit the classroom to find out how their wards are doing, so those who come in to ask are those I usually talk to, that this child needs help in those areas, so at home help the child. The parents there [in the locality where School L is located] don’t have good relationship with the teachers, so only the few who come to the class to find how the child is doing that I try to tell them to help the children.

It becomes necessary for TL4 to collaborate with the few parents who visit the school when he observes that their children have problems, “when I find that this child is good but he doesn’t have the books. This child would come to school without pen.” (TL4) According TL4, he collaborates with parents mainly by inviting them and then advising them:

> … sometimes I find that a child is very good but always sleeping in the classroom, so I call the parent and they come, and say that is the only

> child I have so she/he has to go and fetch water before coming to school, ... so I tell them, it is not good it will affect the child.

Interviews with HL indicated that the school rather encourages parents' and teachers' collaboration in students' mathematics learning, "well, when we feel that for example a child is not all that good in an area, we invite the parent to the school and talk it over with them." Contrary to the views of teachers, HL believed parents were the best group of people, who could support the school in dealing with students' learning difficulties:

> well, the parents' and teachers' collaboration is for the welfare of the children, and they are the best people to help us to handle these children, without them there is little the teachers can do ..., so when there are such problems we fall on them, we share ideas. (HL)

According to HL, apart from learning difficulties, it becomes necessary for teachers to collaborate with parents, "when children misbehave, or when we find out that children are playing truant, or they are in bad company."

6.2.7 Summary of Results from School L

In Section 6.2 findings from the students' activities, as well as interviews with grade four and six teachers, and the headteacher in School L were presented. The findings from students' activities (both at home and school) on fractions showed that students had difficulty identifying fractions in the real life situation. As with the students in School C, students in School L were able to identify a half in the real life situation but they had difficulty identifying a half in the paper and pencil activity. They also used the same fraction name to describe different fractions in the real life situation, in the out-of-school task. Grade four students used the same fraction names to also describe different fractions in the in-school task as well. Students' notion of unit fractions appeared not to be fixed. Their notion of fractions in school was limited to the number of shaded portions divided by the number of partitions in the whole. The most common fraction names that were often used throughout the activities were a quarter and a half.

Grade six students approached measurement informally, using the local unit of measure in all contexts, whilst Grade four students rather used measuring scale most often (with difficulty). Grade four students' used mathematics sentences to justify their answers once they used the measuring scale, whilst grade six students used prose without any mathematical sentence.

Students approached division as a repeated subtraction and multiplication as a repeated addition. The findings also showed that students were able to find the area of a rectangle using the local activity of measuring but had difficulty finding the area of rectangle in the paper and pencil activity. Students used mathematical sentences in the in-school task but not the out-of-school task in some of the activities. In solving problems involving operations on fractions, students often verbalised their answers, followed by oral and written representations. English was a barrier to the students' understanding of the meaning of the word problems.

The findings concerning students' perceptions about mathematics showed that both sets of students had culture-related perceptions about mathematics, their notion about a person using 'mathematics' included "a Kente/twil weaver," "a farmer" and "a local market woman selling rice". They perceived OOSM and ISM as different, and valued ISM more than OOSM. They associated ISM with men and the educated, and OOSM with women and farmers. Grade four students devalued their parents' mathematical practices whilst grade six students valued them.

The findings concerning teachers' and students' language use showed that English language is mainly used in the classroom during lessons. English is used in teaching mathematics generally, and in fractions and measurement specifically. However, all students said they use the local language in communicating with their friends and parents at home. The teachers also use mainly the local language to communicate with their students outside the school's premises.

In spite of the linguistic difficulties students faced reading and understanding the word problem, all except SC41 preferred the use of English as a medium of instruction. This is mainly because they want to be able to speak English.SC41 preferred Fante as the medium of instruction to be able to understand the lesson. However, grade four students' language preference appeared to depend on topics. All preferred to learn measurement in Fante whilst the majority (3 out of 4) of them preferred to learn fractions in Fante.

The majority (6 out of 8) of the students said they thought in Fante during the activity in school, only SL63 and SL64 thought in English. The majority (6 out of 8) of the students said they thought in Fante during the activity at home, only SL42 and SL44 said they thought in English.

Both teachers preferred their students to use English language in their mathematics lessons. However, whilst TL6 (grade six teacher) preferred the use of both English and the local language as a medium of instruction, TL4 (grade four teacher) preferred the use of the local language as the medium of instruction. Unlike the teachers, HL (headteacher of School L) preferred the use of only English language as the medium of instruction. The teachers TL6 and TL4 perceived the Ghanaian school language policy as influencing the use of OOSM in ISM, whilst their headteacher thought otherwise. Responses from the teachers and their headteachers however indicate that teachers make use of OOSM in ISM.

The findings concerning cultural differences students bring forward in mathematics lessons showed that students bring forward cultural differences such as oral computation and finger counting during mathematics lessons. However, the school rejects cultural difference such as finger counting in class. Also teachers reject non-algorithmic approach to problem solving.

The finding concerning parents' and teachers' collaboration was equivocal. Whilst HL said parents and teachers collaborate to help students' mathematics transition, TL6 said he does not collaborate with parents at all. TL4 also said he collaborates with a few parents who usually visit the school, because the parents do not have good relationship with the teachers. However, collaboration between TL4 and the few parents becomes necessary when students have problems affecting their studies.

In the next section the results from School X will be presented. This school is an average achieving school with the most open perception about the use of OOSM in ISM. As with Schools C and L, findings from students' activities as well as interviews with the headteacher and the teacher on social and cultural influences on students' mathematics learning, as well as students' transition experiences between the home and the school will be presented.

6.3 School X

In this section the findings in School X will be presented. These involve findings from the focus group interviews with 4 grade six and 4 grade four students, as well as individual interviews with their teacher (same teacher for both grade levels; TX), and the headteacher of the school (HX). Thus the interview results will be presented in Sections 6.3.1 to 6.3.6.

6.3.1 Children's Activities

In this section the results on how both grade four and six students experienced the concepts mentioned in the introduction of the Chapter Six above at home and school contexts will be presented.

6.3.1.1 Students' activities at home: Identifying and comparing fractions.

Out-of-school task: Table 6.3.1 presents the findings of School X students' identification of a glass one-sixth full of water and a glass one-fifth full of water in Task I at home. The findings from Table 6.3.1 show that as with students in schools C and L, both grade four and six students in School X had difficulty identifying unit fractions in the out-of-school task. None of them was able to identify one-sixth (content of Glass A1), and one-fifth (content of Glass B1) in the out-of-school Task 1. It can be seen from Table 6.3.1 that as with the students in schools C and L, SX43 used the same fraction name to describe the two sets of fractions.

Table 6.3.1. Identification of one-sixth and one-fifth by students from School X at home

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SX61	half	one out of two
	SX62	one-quarter	one out of three
	SX63	one-quarter	half
	SX64	one-quarter	five centimetres
Four	SX41	one out of four	quarter
	SX42	not divided	quarter
	SX43	quarter	quarter
	SX44	quarter	one-third

When the two sets of glasses (A1 and B1) with their contents were presented to both sets of students to compare, all of them (including SX43) identified the content of Glass B1 (one-fifth) to be more than Glass A1 (one-sixth).

The findings from School X students' identification of a glass half full of water and a glass three-fifths full of water in Task II at home are presented in Table 6.3.2. Findings from Table 6.3.2 show that as with students in schools C and L, both grade four and six students in School X were able to identify a half but neither the grade six students nor the grade four students were able to identify three-fifths (content Glass B2). This finding show how difficult it was for students to identify other fractions except a half in the real life situation. In explaining their answers, SX42 explained two fourths as, "it is like a box that is divided into four and two portions shaded," whilst SX44 explained two-thirds as "it is like a box divided into three and two portions shaded."

Table 6.3.2. Identification of half and three-fifths by students from School X at home

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SX61	half	one out of four
	SX62	one and a half	one out of four
	SX63	half	one out of four
	SX64	half	one out of four
Four	SX41	half	two-fourths
	SX42	half	two-fourths
	SX43	half	one-third
	SX44	half	two-thirds

Comparing the contents of the two Glasses, however, all grade six and four students identified the content of Glass B2 to be more than Glass A2.

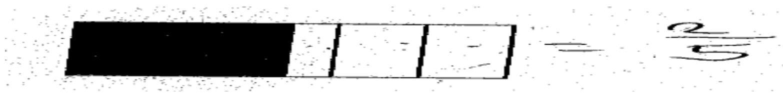
The findings from out-of-school Task 1 and Task II appear to show that some of the students' notion of a half is not fixed. A half could be at the midpoint or above the midpoint (SX61).

In all the two out-of-school tasks relating to the identification of fraction (Task I and Task II), the most common fraction name that was used often by grade six students was a half (five times), followed by, "one out of four" (four times). The most common fraction name that was used often by grade four students was a quarter (six times), followed by a half (four times).

In- school task: The findings from in-school task on fractions at home also showed that both grade six and four students had difficulty identifying fractions. As with the students in schools C and L, both grade six and four students in School X also tended to concentrate on the number of partitions in the whole and the shaded portion to identify the fraction they were dealing with, rather than looking at the shaded portion in relationship to the whole. For example, in identifying one-fifth, they counted five divisions and one shaded portion, and presented their answers as one-fifth. They were also able to identify one-sixth in the in-school Task I.

Grade six students were also able to identify three-fifths in in-school Task II, without problems. They, however, had difficulty identifying a half in in-school Task II (a fraction the majority of them were able to identify in the out-of-school task). They identified it as two-fifths. Grade four students however had difficulty identifying both a half and three-fifths. They identified a half as a quarter, and three-fifths as one-third (see Figure 6.3.1).

Grade six students' presentation



Grade four students' presentation

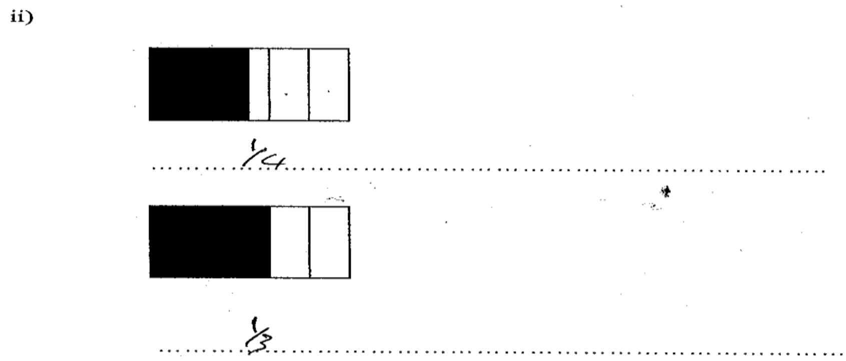
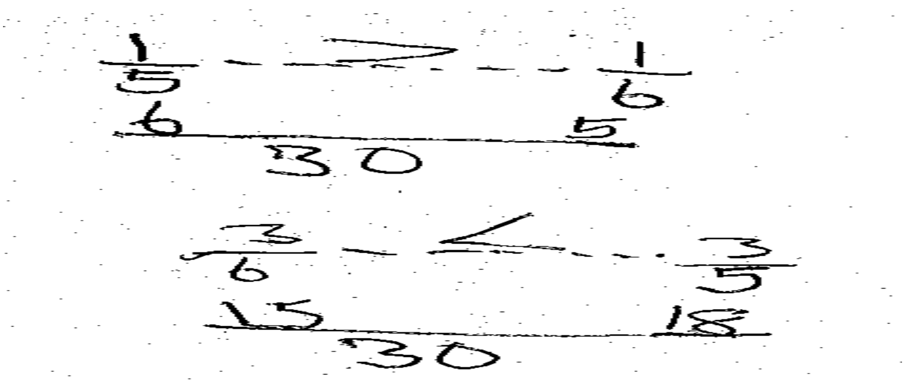


Figure 6.3.1. School X students' presentation on identification fractions in-school Task II at home.

It could be seen from the diagram in Figure 6.3.1 that grade four students counted each of the shaded portions as one part of the whole. This is an indication that for these students, sharing does not necessarily mean sharing into equal parts. Also their notion of part-whole relationship in fractions was limited to the number of shaded portion(s) divided by number of divisions in the whole.

In comparing fractions, both grade six and four students were able to use the correct symbols to compare the two sets of fractions. They were also able to justify their correct answers, as shown in Figure 6.3.2. It could be seen from Figure 6.3.2 that grade four students were able to use diagrams to represent three-fifths (a fraction they could not identify in in-school Task II). This confirms that their notion of fractions was limited to number divisions in the whole divided by the number of shaded portion(s).

Grade six students' presentation



Grade four students' presentation

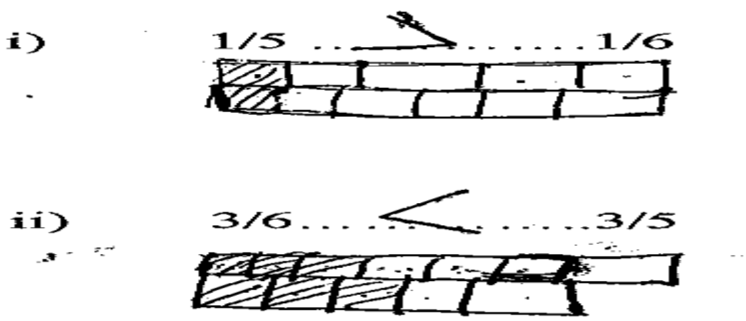


Figure 6.3.2. School X students' presentation on comparing fractions in in-school task at home.

6.3.1.2 Students' activities at home: Division of fractions/measurement of capacities.

Out-of-school task: Both grade six and four students approached their solution in the out-of-school task in similar manner (an informal way), using an empty margarine tin, to arrive at their various answers. The two sets of students, however, approached the sharing differently. Grade six students set three containers, and went round each of these containers with a cup of maize to find out what each one would get, before finding the total number of cups of maize through oral computation as, "ten and half"(chorus). SX62 presented the group's solution in meaningless prose, as shown in Figure 6.3.3.

Grade four students set three containers, and then went round each of the containers with a margarine cup of maize three times. As with the grade four students from School C, SX42 (who was the eldest amongst them) was given one cup from the remaining. This made SX42's share of the maize four cups. The remaining (which measured a half cup) was put aside because, "the maize was not sufficient." (SX44) They presented their final answer as 4, 3, 3 and a half. They could not write down their solution neither in prose nor in a mathematical equation.

Grade six students' presentation

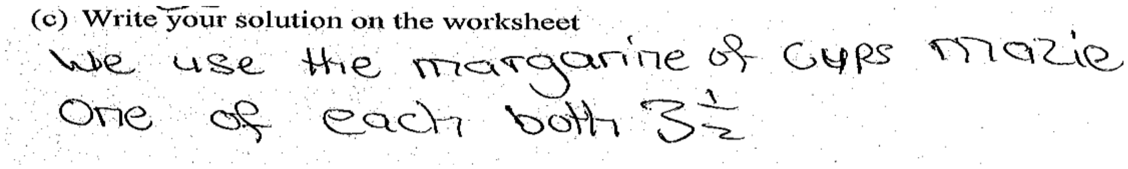

(c) Write your solution on the worksheet
We use the margarine of cups mazie
One of each both $3\frac{1}{2}$

Figure 6.3.3. School X students' presentation of 10.5 divided by 3 in out-of-school task at home.

In-school task: As with the out-of-school task, both sets of students approached their solution to the in-school task in an informal way, using an empty margarine cup. Grade six students followed the same procedure they used in sharing the maize in the out-of-school task to share the rice, to arrive at their correct answers of $10\frac{1}{2}$ and $3\frac{1}{2}$ respectively. Thus the students found what each person would get (that is, $3\frac{1}{2}$) before finding the total number of cups of rice as ten and a half cups, through oral computation ($10\frac{1}{2}$). As with the out-of-school task, they presented their solution in meaningless prose as, "we use to margrine [sic] cups of rice."

The majority (3 out of 4) of the grade four students requested a measuring scale, once they were presented with the rice to measure, and share amongst three people in the in-school task. Only SX43 requested the local unit of measure ("Olonka"). SX41 puts the bag of rice on the measuring scale, but none of them could read it, they remained silent. SX44 later said, "sir [referring to the researcher] we want the margarine cup." SX42 explained, "we have not used some [scale] before." With the help of other group members, SX43 measured all the rice into two containers, and had ten and a half cups. They verbalised what each will get as three and half, in chorus. Unlike the out of school task, where they shared according to seniority, they rather shared the rice equally amongst the three in the in-school task. Thus each had three and half cups. Here also they could not write down the approach they used in sharing.

6.3.1.3 Students' activities at home: Multiplication of fractions/measurement of capacity.

Out-of-school Task: As with the students in schools C, both grade six and four students in School X also approached their solution informally, by calling out their answer first and then providing oral computation to justify their answers. They provided written presentation of their answer once they were requested to do so.

When the problem was presented to students, for grade six students SX64 began to count the fingers (silently) and orally said, "nineteen and half" (which was the correct answer). SX64 explained his solution orally using the decomposition method as, “six plus six plus six is eighteen, and half plus half plus half is one and a half, eighteen plus one and a half is nineteen and half.” SX62 presented the group’s solution using repeated addition, as shown in Figure 6.3.4.

Grade for students gave varied responses, SX43 counted the fingers (silently) and orally said, “nineteen and a half,” SX43 explained his solution saying, “put that of two boys together to get thirteen, and add six and a half to get nineteen and a half,” SX42 said, “nineteen” and explained his answer as, “three people, when they shared it [maize], they will get eighteen and half, plus half, so it is nineteen,” SX41 said, “eighteen, because three people, when they share eighteen cups, each will get six and half.”

Grade six students’ presentation

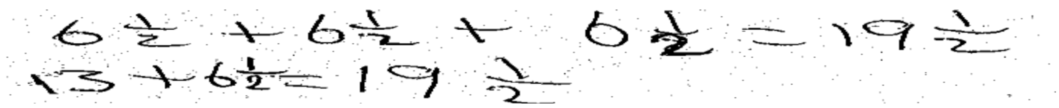
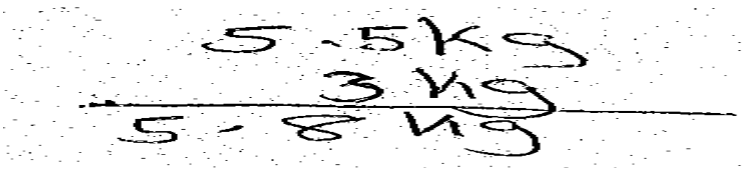


Figure 6.3.4. School X students’ presentation of 6.5 times three in out-of-school task at home.

In-school Task: Neither the grade six students nor the grade four were able to solve the word problem involving 5.5kg times three correctly. Both sets of students read the question with a lot of difficulty. The difficult words for grade six students were “quantity”, ‘bought”, “whilst” and “Kg”. Grade six students read bought as “brought” so they interpreted the question as involving addition, “sir we added...” (SX61). They presented their solution as an addition sentence, as shown in Figure 6.3.5. Unlike the out-of-school task, they did not attach meaning to the addition they were doing in the in school task.

The difficult words for the grade four students included “quantity” and “whilst”. They interpreted the demands of the question wrongly as, “Ama bought 5.5kg of rice and Esi bought three times of the rice, so how much did Esi buy?”(SX41) They presented their solution in prose based on their interpretation of the question, as shown in Figure 6.3.5.

Grade six students’ presentation



Grade four students’ presentation

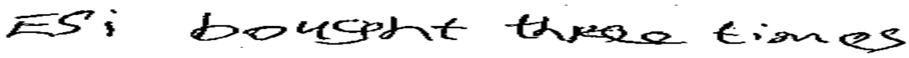


Figure 6.3.5. School X students’ presentation of 5.5 times 3 in out-of-school task at home.

6.3.1.4 Students’ activities at home: Addition of fractions and measurement of area.

Out-of-school task: Using the same approach as grade six students in Schools C, grade six students in School X measured four poles, however, they ignored the remaining part, “yen fa no de oye four [let us round it to four].” (SX64)

Unlike grade six students who rounded their answer, grade four students measured four “poles” and guessed the remaining area. They got divided over what the remaining area should be. SX41 and SW44 said it was four and a half because, “what was left was not up to one.” (SX44) SX42 and SX43 said it was four and a quarter because, “what was left was not up to a half.” (SX42)

In-school task: Both grade four and six students had problems understanding the word problem involving a quarter plus two quarter. SX64 read the word problem without difficulty. However, even though SX63 orally mentioned the correct answer as, "three out of four," it appeared students could not figure out what the question required them to do. This was evident in the excerpts of the interviews with students below:

> **SX63**: the answer is three out of four
>
> **SX62**: it is one out of four
>
> **SX64 & SX61**: [nod their head in support of SX62]
>
> **R**: SX63 how did you get the answer?
>
> **SX63**: [silent, could not explain]
>
> **R**: SX64 why is it one out of four?
>
> **SX64**: [explains in Fante] Papa Kojo gave Abena one out of four of an orange and Ekua two out of four of an orange, and the question says what did each of them get?
>
> **R**: Write your solution on the worksheet
>
> **SX64**: [writes the solution in prose to reflect his interpretation of the question, as shown in Figure 6.3.6.]

Grade four students were not able to solve the word problem solving involving addition of a quarter and two quarters correctly, despite the fact that some of them were able add halves in the out-of-school Task III. Even though SX42 was able to figure the out the problem as involving addition of fractions, they could not come out with the correct answer. SX41 presented the group's answer only as three-eighths, without any mathematical equation. SX43 explained their answer orally in Fante as, "we added two to one to get three, and four to four to get eight ..."

Grade six students' presentation

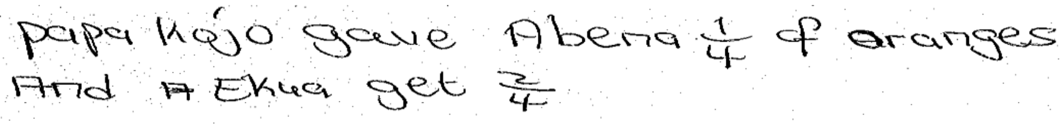


Figure 6.3.6. School X students' presentation of solution to two-quarters plus a quarter.

However, the grade six students were able to solve the problem involving the area of a rectangle in the in-school task. In solving the in-school task which involved finding the area of 2cm by 3.5cm rectangle, SX64 read the question without problems. He orally called out the correct answer as seven, wrote the formula for finding the area of a rectangle (Area = L x B) and solved to get the correct answer as 7cm^2.

In Sections 6.3.1.5 to 6.3.1.8 the result of students' activities in school will be presented. As with School L, the activities in school were the same task students went through at home. Students' activities in school therefore covered four areas, namely identifying and comparing fractions, division of fractions/measurement of capacities, multiplication of fractions/measurement of capacity, and addition of fractions and measurement of area (see Section 6). Results from student activities in school are presented below.

6.3.1.5 Students' activities in School: Identifying and comparing fractions.

Out-of-school task: Table 6.3.3 presents the findings from the identification of a glass one-sixth full of water and a glass one-fifth full of water in School X. The findings in Table 6.3.3 shows that both grade six and four students had difficulty identifying unit fractions in the out-of-school task in school. As with their activity at home, none of them was able to identify one-sixth and one-fifth in Task I. SX62 identified the content of Glass A1 as one-third, because "the water is just a little." (SX62). SX41 explained one out of four saying, "take a box, divide it into four and shade one." SX43 explained one-third as, "something in the third position." Thus SX43 was thinking in terms of ordinal numbers, an indication of a guessed answer. The findings also show that with the exception of SX42 and SX43, all students used the same fraction name to describe the two sets of fractions.

Table 6.3.3. Identification of one-sixth and one-fifth by students from School X in school

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SX61	one-third	one-third
	SX62	one-third	one-third
	SX63	one-third	one-third
	SX64	one-third	one-third
Four	SX41	one out of four	one-fourth
	SX42	one out of four	one-third
	SX43	one out of four	one-third
	SX44	one out of four	one-fourth

However, when both grade four and six students were asked to compare the content of the two glasses (A1 and B1), all of them said the content of Glass B1 was more than Glass A1.

The summary of findings from identification of a glass half full of water and a glass three-fifths full of water in School X is presented in Table 6.3.4. The findings from Table 6.3.4 show that both grade six and four students had difficulty identifying three-fifths (content of Glass B2). However, whilst all grade six students were able to identify a half, unlike the activity at home, all grade four students identified it at two over four. SX44 explained two out of four saying, "divide a diagram, a box, into four and shade two portions." It could also be seen from the findings in Table 6.3.4 that some of both grade six and four students continued to use the same fraction names to describe the two sets of fractions (SX64, SX41 and SX43).

Table 6.3.4. Identification of half and three-fifths by students from School X in school

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SX61	half	Two-thirds
	SX62	half	Three over three
	SX63	half	Two-thirds
	SX64	half	half
Four	SX41	two out of four	two out of four
	SX42	two out of four	two out of three
	SX43	two out of four	two out of four
	SX44	two out of four	two out of three

However, in comparing the contents of the two glasses (A2 and B2), all grade six and four students identified the content of Glass B2 to be more than A2. In all the two activities on the identification of fractions in the real life situation, the most common fraction name that was used often by grade six students were one-third (eight times) and a half (five times). Whilst "two out of four" (six times) and "one out of four" (four times) were used often by grade four students.

In-school-task: Findings from the in-school task on fractions in school also showed that both grade six students and four students had difficulty identifying fractions. As with the students in schools C and L, students in School X also tended to concentrate on the number of partitions in the whole, and the shaded portion(s) to identify the fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole. Both grade six and four students were therefore able to identify one-sixth and one-fifth in the in-school Task1, without problems. They were able to identify three-fifths in Task II, but rather had difficulty identifying a half. As with the activity at home (see Figure 6.3.1), grade six students identified half as two-fifths whilst grade four students identified it as three-fifths, thus using the same fraction name to describe the different parts of the whole (see Figure 6.3.7).

Grade four students' presentation

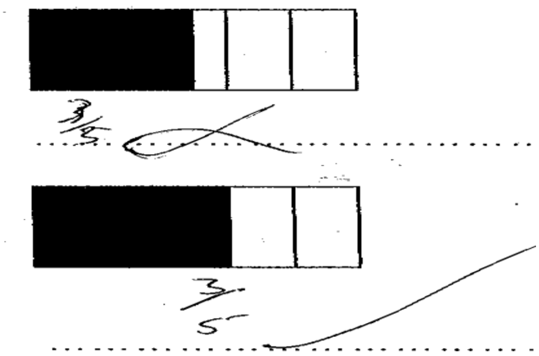


Figure 6.3.7. School X students' presentation on identification of fraction in in-school task II in school.

As with the in-school activities at home (Section 6.3.1.1), both grade four and six students were able to use the correct symbols to compare the sets of fractions. Both sets of students justified their correct answers using the same approach they used in the activities at home (see Figure 6.3.1). However, grade four students partitioned the wholes in their diagrams unequally, confirming the earlier observation that division in fractions as far as these students are concerned does not necessarily mean equal divisions (see Section 6.4.1.1).

6.3.1.6 Students' activities in School: Division of fractions/measurement of capacities.

Out-of-school Task: Both sets of students used informal approach in solving the problem. Unlike their activities at home, grade six students initially requested a measuring scale during their activities in school, "sir stand on scale"(SX64). SX64 put the maize on the scale but none could read it (all remained silent). They finally said in chorus "sir we want a margarine cup". With the help of the other group members SX62 went through the same procedure they followed at home (see Section 6.3.1.2), to arrive at their correct answers of ten and a half and three and a half respectively. SX64 presented the group's solution only in prose, without any mathematical equation, as "we use margarine cups to share the mazie [sic] all of them get [sic] $3\frac{1}{2}$."

Grade four students approached the task in the same way as they did in the in-school activities at home. SX42, with the help of other group members, measured the total amount of maize into two containers (they had ten and a half cups). In sharing amongst three people, SX42 orally used repeated subtraction to solve the problem:

> if we give one person three cups, and the next person three cups, that would be six cup, if we give the next person three cups, that would be nine cups. It will be left with one and a half cups. We will give two of them one cup to share half, half, and give the remaining half to the next person, so each of them would get three and a half cups.

As usual, written presentation of their explanation was a problem; SX41 attempted to present the solution in prose, without any mathematical equations as, "Three people shared the mazie [sic]."

In-school Task: Both grade six and four students approached their solution in an informal way using a margarine cup (as a unit of measure). However, the two sets of students solved the problem differently. As with the out-of-school activity, grade six students found what each person would get, by going round each of the three containers with a margarine cup of rice. They found the total number of cups of rice (which was ten and a half cups) through oral computation. SX62 presented the group's solution in prose as, "we use to margarin [sic] cup to share rice to the 3 people all of them get $3\frac{1}{2}$."

For the grade four students, SX43 set two containers, and measured all (ten and a half cups) of the rice into the containers. They orally said each will get three and a half cups, and explained their solution as shown from the excerpt of the interviews below:

> **SX42**: if we share, each of them [the three people] will get three that would be nine; we will be left with one
>
> **SX41**: no, one and half
>
> **SX42**: ok each will get half [from the remaining], and that would make it three and a half [for each]
>
> **SX44**: [presented the solution in prose as, "3 people shared 10 and half rice."]

6.3.1.7 Students' activities in School: Multiplication of fractions/measurement of capacity.

Out-of-school Task: As with the out-of- school task at home, both grade six and four students used the informal approach of verbalisation of answers before justifying it. For the grade six students, SX64 counted his fingers (silently), and called out the correct answer as, "nineteen and a half." SX62 used the decomposition method to present the group's solution, as shown in Figure 6.3.8.

For the grade four students, immediately the researcher presented the problem SX43 orally called out the answer as, "nineteen and a half." They presented their written solution using the decomposition method as, "6+6+6+1+half =19 and half"

Grade six students' presentation

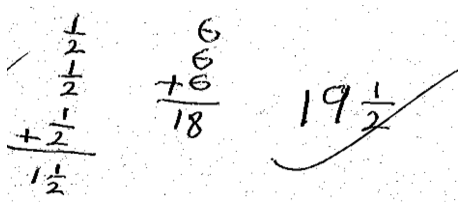


Figure 6.3.8. School X students' presentation of 6.5 times three in out-of-school task, in school.

In-school Task: As with their activities at home, both grade six and four students had difficulty reading and understanding the word problem involving 5.5kg times three. Some of the difficult words for the grade six students included "bought", "did", "whilst" and "quantity". The difficult words/terms for grade four students included "quantity" and "whilst".

Grade six students got divided over the solution to the problem. SX64 said the question required them to multiply, because of "three and times." Thus SX64 wrote the solution as "3x3=9". SX62 interpreted the question as involving addition because of "bought", which she interpreted as "brought", as in the past tense of bring. She presented her solution as "5.5kg +3=5.8kg".

For grade four students, SX42 explained the demands of the question as, "Esi bought rice three times..." They finally presented their solution in prose as "Esi bought three time the quantity of rice Ama bought" (SX42).

6.3.1.8 Students' activities in School: Addition of fractions and measurement of area.

Out-of-school task: As with their activities at home, grade six and four students approached the activity differently. Grade six students measured four poles and ignored the remaining part. After measuring four "poles" SX64 said, "let us take it to be four," He went on to present the answer as 4, instead of $4\frac{1}{2}$.

As with their activities at home, grade four students measured four poles, but this time all of them guessed the remaining part to be a quarter. SX41 presented the group's solution as "4 and queter [sic]".

In-school task: Both grade six and four students were able to read and interpret the demands of the question correctly, "it says ... if you put the two together what will that be?" (SX42) The two sets of students, however, solved the word problem involving the addition of two quarters to a quarter wrongly. For the grade six students SX64 orally called out the answer as, "three over eight." He went further to explain his answer as, "one plus two is three, and four plus four is eight." Both grade six and four students presented their solution using a mathematical equation as $\frac{1}{4}+\frac{2}{4}=\frac{3}{8}$.

Grade six students were not able to find the area of 3.5cm by 2cm rectangle correctly. SX62 quoted the formula for finding the area of rectangle as "Area = L x B" and then substituted the value for the length and the breath in the formula. However, they could not evaluate 3.5cm times 2cm, even though they were able to evaluate 6.5 plus 6.5 plus 6.5 in the out-of-school task. They presented their final answer as $3.10cm^2$.

For both the Out-of-school and In-school tasks at home and in school, both the grade six and four students used the Fante language in communicating amongst themselves. With the exception of SX64 who said he used both the Fante and English in thinking, all students (including grade four students) said they thought in Fante throughout the activities, “we use Fante to think about it.”(SX62). They explained further saying, “we use English to read, and try to understand in Fante, before we do it” (SX42)

6.3.2 Students’ Perceptions

6.3.2.1 Students’ perceptions about mathematics.

Interviews with both grade six and grade four students showed that both sets of students had culture-related perception about mathematics. With the exception of “a Kente/twil weaver” which half (2 out of 4) of the grade six students identified as a person who does not use mathematics, all grade six students identified “a local market woman selling rice,” “a driver’s mate,” and “a farmer” as people who use mathematics. Interviews with grade four students also revealed that with the exception of “driver’s mate,” who students identified as somebody who does not use mathematics, they identified all the pictures, including “a local market woman selling rice”, “a farmer” and “a Kente/twil weaver” as people who use mathematics. Both sets of students perceived OOSM as being different from ISM. All grade six students said, “they don’t look alike,” “we use school mathematics for examinations; if you don’t learn it you will fail.” (SX62) All grade four students also perceived OOSM and ISM as being different, and unrelated.

All grade four and six students also valued ISM more than OOSM, “school mathematics is important, because of examinations.” (SX63); “We can’t go to the office and then use ‘Olonka’ to measure, so school mathematics is more important.” (SX44). However, all grade four students believed “school mathematics is important, but home mathematics is also important.” Whilst the grade six students associated ISM with accountants, teachers, and OOSM with mothers, traders, farmers, grade four students associated OOSM with the illiterate women, “our mothers who did not go to school.” (SX42) They associated ISM with the educated, “school children like us.”(SX42)

6.3.2.2 Students' perceptions about parents' knowledge.

Findings from interviews with both grade six and four students revealed half of grade six students and all grade four students valued their parents' knowledge. SX63 and SX61 devalued their parents' mathematical knowledge, "they know only home mathematics..." (SX63), "...we learn differently from them, orally they teach them six plus six and they understand it," (SX63) "parents mathematical practices are different from ours, their approach is different; they don't know LCM." (SX61) "They [parents] work mathematics like us but in their heads; they do addition and so on" (SX63). SX64 and SX62 valued their parents' mathematical knowledge, "they know some mathematics" (SX62). SX62 even perceived the illiterate father as knowing some mathematics; "he knows maths." All of the grade six and four students, however, appeared to see some worth in their parents' mathematical practices, "yes, it [parents' mathematical practices] is important." (chorus, grade four students); "it is useful because that is what helps them to sell ..." (SX63)

6.3.3 Language Use and Preference

6.3.3.1 Students' language use and preference.

Findings from interviews with students showed both grade six and four students as saying they use Fante in communicating with their parents because, "... they [parents] like Fante," (SX61) "we speak English in school but at home we are free to speak Fante." (SX62) All of them also said they use Fante in communicating with their friends at home because, "some friends don't go to school," (SX63) "this helps us to converse." (SX64)

However, findings concerning language use in class indicated differences in language use among the grades six and four students. The majority (3out of 4) of the grade six students said they use English in class when there is a mathematics lesson. Only SX64 said, "we speak English and Fante." All of them said they speak English in class when there is no lesson. Students explained the situation to the researcher saying, "sir when we are at home we speak a different language and when we come to school we speak another language," (SX61) "in school if you speak Fante they would cane you, so you have to speak English." (SX62)

Grade four students said they use both English and Fante in communicating with the teacher, and Fante in communicating with friends in class, whether there are lessons or no lesson. This is because, "sometimes we cannot express ourselves." (SX42). However, they use English with the teacher and Fante with friends when there are no lessons. This is because, "that is what all students usually do." (SX43). According to SX42 they use English with the teacher because, "we want to understand and speak English."

All grade six students said they use English in communicating with teachers, and Fante with their friends, during break time because, "when you speak Fante with the teacher he would ask you to leave his presence," (SX64) "he would cane you before he asks you to leave." (SX63) All grade four students said they use Fante in communicating with both teachers and friends outside classroom during break time because, "we are playing." (SX42)

Interviews with children also showed the grade six students as saying their teacher uses both English and Fante in teaching mathematics generally but uses English in teaching both fractions and measurement. All grade four students also indicated that their teacher uses both English and Fante in teaching mathematics generally, and measurement and fractions specifically.

The findings concerning students' preferred for language of mathematics showed that the two sets of students differed in their language preference. The grade six students said they preferred to study mathematics generally in both English and Fante, and concepts of fractions and measurement specifically, also in both English and Fante because, "we don't understand the lesson in English so the Fante helps"

(SX64), SX61 and SX63 explained further, “we want the English also, so that we can speak and write English ...,” (SX61) “Fante for us to understand better.” (SX63)

The grade four students said they preferred to learn mathematics in English, “to be able to communicate in English when we grow.” (SX41) All of them, however, preferred to study fractions in Fante because, “when he uses English we don’t understand it.” (SX44) They also preferred to learn measurement in English and Fante, “for us to understand the lesson and also to learn English.” (SX43)

6.3.3.2 Teacher’s language use and preference.

Results from interviews with the teacher in School X (TX) showed him as saying that students use only the English language in class when there is mathematics lesson, “English Language, because the government policy says at the upper primary we should use the L2, which is the English language.” (TX) According to TX, students use “both L1 and L2 (Fante and English)” in class when there is no lesson, and also during break time.

Interviews with TX showed him as saying he uses a mix of English and Fante in class whether or not there are lessons because “English is the approved medium of instruction ... [and] Ghanaian language is a subject being taught in school, and it is examinable” (TX). TX said he uses “more of English than Fante,” in teaching mathematics generally because, “there are certain materials that has got the local name, For instance the ‘Oware’ game, ‘Olonka’ tins.” TX said he uses, “more of English and a little Ghanaian language,” in teaching fractions and measurement. He uses both languages during break time, and when he meets students in town because:

> English is the approved medium of instruction; whenever you interact with students in English it polishes the student, and one way or the other we are more or less teaching him outside classroom, through the interaction… (TX)

TX prefers students to use English in classroom during mathematics lesson because:

> English has been the medium of instruction in the classroom, and then English language itself is a subject being taught, and it is examinable. Myself being the mathematics teacher, I more or less help the English teacher in that direction. (TX)

TX would also prefer to use a mix of English and Ghanaian language (but more English) in teaching mathematics generally, and fractions and measurement specifically. This is because English is the approved medium of instruction. He prefers Fante because local materials he usually uses in mathematics lesson have local names, also Fante is a subject which is studied in schools.

6.3.3.3 Headteacher's language use and preference.

According to the headteacher of School X (HX), teachers use English language in teaching mathematics because, "they have been asked to use English in teaching any subject from the upper primary to the BS9 [grade nine], but at the lower primary we have to use both, but we use English to teach English." The findings showed HX as also saying students use the local language when there is no lesson, but they are forced to use the English. According to HX, some students "use Fante and some use English" during break time.

Unlike the students and TX, HX prefers teachers to use English language as a medium of instruction because "when the children go to the examination room they have to read and understand before they solve the mathematics..." (HX)

6.3.4 The Use of OOSM in ISM

6.3.4.1 Policy influences.

Interviews with Teacher X (TX) indicated that he was aware of the language policy of Ghana, which requires the use of Ghanaian language at the lower primary and English language from the upper primary:

> from P1-3, L1, [that is the local language] should be the medium of instruction, that is the Ghanaian language should be the medium of instruction, with the exception of where the classroom teacher is coming to teach English that he uses English. For all other subjects, the L1, that is the Ghanaian language should be the medium of instruction, and with the upper primary the medium of instruction is English language, with the exception of Ghanaian language being a subject.

According to TX the language policy affects the use of OOSM in ISM, because the language of instruction from grade four does not permit the easy use of OOSM in ISM. This is reflected in his statement:

> to the best of my knowledge the language policy does affect mathematics teaching in class, especially in the upper primary, where there are some standardised materials that has to be used in teaching mathematics. For instance the "Olonka" tin, which has the local dialect as the name.

Unlike TX, interviews with headteacher of School X (HX) indicated that HX was not aware of the language policy of Ghana:

> it is English; from P4 going it is a must that we have to use English. From P1-3 when teaching English you have to use English only, but when teaching mathematics you can use English, but when you reach a place that the children cannot understand then you come in with the L1 [local language], so at the lower primary it is both the English and Fante.

According to HX, the language policy does not affect the use of OOSM in ISM:

> no it does not affect it, because as I said previously, when the children go to the examination room everything is in English; so they have to practice, so that when they go to the examination room they would not find it difficult reading it.

HX believes teachers can use the local names to support the use OOSM in ISM, "because we do not have English name for 'atuwudo', 'Olonka' and so on so, we can use their [local] names." (HX)

6.3.4.2 Classroom practices.

Teacher X (TX) indicated he makes use of out-of-school cultural notions in measurement and fractions, in ISM. According to TX:

> before I start the lessons, I need to brainstorm the pupils to come up with how they measure in their various homes. Then I relate this relevant point pupils come out with to the day's lesson, by introducing to them the SI units and materials like the measuring tape. The previous knowledge of the pupils becomes the basis for the development of the lesson.

He explained further that, "out-of-school practices in measurement help the kids a great deal; they arouse the pupils' interest for the upcoming lesson..." The findings also showed TX as saying:

> ... before I start my lesson I draw on pupils' knowledge on sharing that they engage in at home, by giving them things to share. The way they share at home will be exhibited in class, because this is how they have been introduced to, maybe by their parents or ..., so it is the school that when they come changes may occur.

TX perceived out-of-school practices in fractions as enhancing children's ability to count:

> in supporting the children learning, I think sharing enhances children's ability to count. When sharing, they might know that I have given Kwesi three and I have given Kojo four, and out of that it is enhancing their ability in counting, and also share items equally among people.

TX, however, highlighted that the problem of unequal sharing occurs, “interference occur, the problem of sharing unequally usually occurs.” (HX)

Interviews with headteacher of School X (HX) showed HX as also saying teachers make use of OOSM through mental drills:

> in the morning some do mental; it may be story telling form, so it is also part of mathematics. For example you ask the child when coming to school your mother gave you 20 pessewas [16 cents] and gave your sister 10 pessewas, if you add them together how much do you get? It is also part of mathematics. ... (HX)

HX perceived OOSM as being very important for students at all levels, “it is useful at all levels...” HX believed it is more important for students who drop out of school at the end of grade nine, “it is important because some children when they finish school they wouldn’t get the help to go to the secondary school, some of them would like to go into trade and it [OOSM] can help them …”

6.3.5 Cultural Differences Students Bring Up in Mathematics Lessons

According to Teacher X (TX) the cultural differences students usually bring forward in class involves finger counting, “whenever we engage in counting you may see some of them counting their fingers and toes, ... when measuring some also use their span in measuring.” (TX) The results further revealed TX as saying he discourages finger counting in his class:

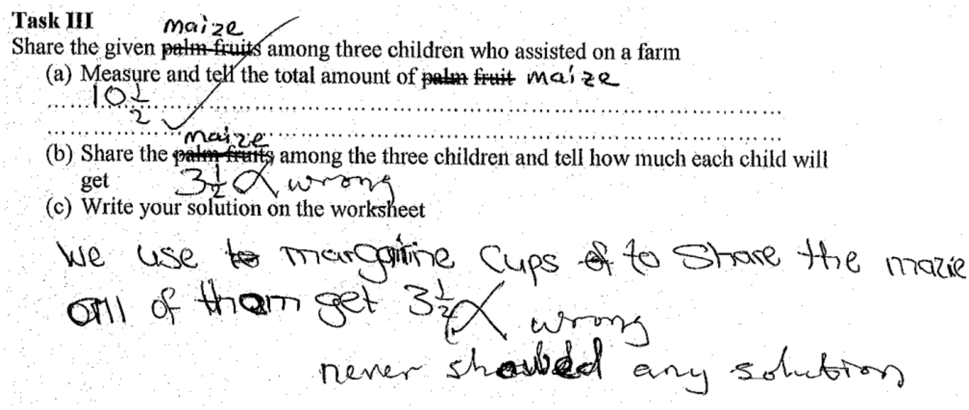
> I discourage them, but I don’t discourage them outright, because we have individual differences and the learning abilities of one pupil differ from the other, I exercise restraint with them and then try to encourage them to use the counters instead, ..., as time goes on they would learn to resort to whatever is being done in the class, like the counters.

TX said he handles cultural difference by not discouraging it outright because, “individual difference exists among children, so you need to be patient with them.”

Analysis of TX’s marking of students’ worksheets, however, brought to light that as with TC, he rather rejects some of the cultural differences students bring with them. He rejected non-algorithmic approach to mathematics problem solving. This was evident in TX’s marking of students’ activity, which involved 10.5 divided by three. In this activity students approached the division using repeated subtraction through the use of margarine cup and presented their solution in prose, but TX rejected this approach outright (see Figure 6.3.9).

The analysis of TX’s marking of students’ worksheets further revealed that TX rejects rounding of numbers, which is also a cultural influence from home. In measuring the area of two and quarter units by two units rectangle, grade six students measured four “poles” (four square units) and ignored the remaining part. They therefore rounded their answer as four. As usual, TX rejected this approach outright (see Figure 6.3.9).

Use of margarine cup to solve 10.5 divided by 3



Task III

maize

Share the given ~~palm fruits~~ among three children who assisted on a farm

(a) Measure and tell the total amount of ~~palm fruit~~ maize

……$10\frac{1}{2}$……………………………………………………………………

………………………………………………………………………………

(b) Share the ~~palm fruits~~ maize among the three children and tell how much each child will get $3\frac{1}{2}$ wrong

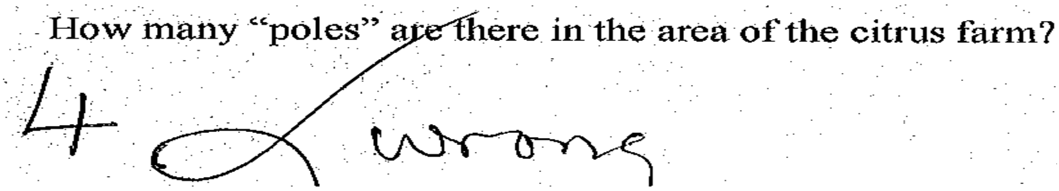
(c) Write your solution on the worksheet

We use ~~to~~ margarine Cups ~~of~~ to Share the mazie

all of them get $3\frac{1}{2}$ wrong

never showded any solution

Rounding in measurement



How many "poles" are there in the area of the citrus farm?

4 wrong

Figure 6.3.9. TX's handling of cultural difference from marking students' activities in school.

Interviews with headteacher of School X (HX) showed HX as saying students usually bring culture differences from home, through their previous knowledge from home, "bottle tops they use to play at home and sometimes they bring it to school ..., also previous knowledge from home." According to HX teachers use cultural differences which are good for students, "they all share, if it is good for them they take it." (HX) This confirms TX handling of cultural differences that are perceived to be bad in Figure 6.3.9. Interviews with HX further showed her as saying that teachers discourage the use of cultural differences such as finger counting through negotiation:

> ... some children prefer using their fingers to counters. Teachers do not stop them from using the fingers, but explain things to them. They explain why they should not use the fingers. We have only ten fingers, but if we are doing addition with sum more than ten you can't use your ten fingers. (HX)

According to HX teachers handle cultural difference by explaining to students why they should not use the out-of-school approach:

> it is their duty to do it; as a teacher you have to explain things to them, ... for instance, if the child is given ten plus ten, if you use the finger counting it would be difficult for the child to solve the problem. (HX)

6.3.6 Parents' and Teachers' Collaboration in Students' Mathematics Learning in School

Findings concerning parents' and teachers' collaboration in students' mathematics learning showed TX as saying, "I collaborate with them [parents] so much, especially when they come to PTA meeting." TX collaborates with parents because:

> ... mathematics is a subject that needs constant practice. Some children being so truant, would never stay at home and take the mathematics book and learn, so I edge the parents to sit their kids down, and then learn some mathematics, since they tend to forget when they don't practice. (TX)

According TX he collaborates with parents at anytime he meets them, "at anytime I meet parents I tell them..." TX said he collaborates with the parents of brilliant students as well, "...they may tend to forget, and in order not for compliancy to set in the brilliant pupils we encourage them to learn more..." TX said he collaborates with parents, "when they come for PTA, or anytime any parent visits the school, I call him or her and talk things over with him, concerning the well being of the child, as far as mathematics is concerned." (TX)

HX said, “we [the school] have been asking them [parents] to come to the school, and have a look at their children’s book, ...” Interviews with HX revealed that parents are invited to the school in order to make them aware of the needs of their children, “when the parents come they can see that oh my child needs help, so the teacher would tell the parents the weak points.” According to HX the school generally finds parents’ and teachers’ collaboration necessary when, “we want the parents to know the performance of their children, and also some children absent themselves too much ...”

6.3.7 Summary of Findings from School X

In Section 6.3 findings from students’ activities, as well as interviews with grade four and six teacher, and headteacher of School X were presented. The findings from students’ activities on identification of fractions, and comparing fractions showed that students had difficulty identifying fractions, especially in the real life situation. They were able to identify a half in the real life situation in the out-of-school task but not the other fractions (one-sixth, one-fifth and three-fifths). However, they had difficulty identifying a half in the paper and pencil activities in the in-school task.

In identifying fractions in the focus group interviews, students used the same fraction names to identify the different fractions in the out of school task. As with the grade four students from School L, grade four students from School X also used the same fraction name to identify different fractions in the paper and pencil activities in the in-school task. The findings showed that students’ notion of unit fractions was not fixed. The most common fraction names that were often used throughout the activities involving the identification of fractions in the real life situation were a half, one-third, and a quarter.

Students approached measurement in an informal manner, using an empty margarine tin in all contexts. Informal approach of verbalising answers, followed by oral and written presentations was used by students throughout the activities involving word problem solving at home and in school premises. Students rounded measurements and made use of finger counting in solving the problems.

Both sets of students solved addition of mixed numbers by means of decomposition method, and division by way of repeated subtraction. Multiplication was approached as repeated addition throughout the activities. Grade four students did not think of sharing as involving sharing into equal parts. Even though students added fractions in out-of-school task without problems, using oral computation, they had difficulty doing the same in paper and pencil task.

As with the grade four students in School C and School L, both sets of students from School X had difficulty understanding the demands of word problems. Thus English language was a barrier. Also students used mathematical sentences mainly in the in-school tasks as compared to the out-of-school task.

The findings concerning students' perceptions about mathematics from the focus group interviews showed that both sets of students had culture-related perceptions about mathematics. Their perceptions about persons who make use of 'mathematics' in their work included "a local market woman selling rice," "a farmer" and "a Kente/Twil weaver." They, however, perceived OOSM and ISM as being different, and valued ISM more than OOSM. They associated ISM with the educated and OOSM with women and others such as farmers.

The findings on language use showed all the research participants as saying English is mainly used in the school. The finding also showed that Teacher X uses mainly English and a little Fante in teaching mathematics generally, and fractions and measurement specifically. Teacher X would also prefer students to use English during mathematics lesson. However, all the students said they use Fante to communicate with their parents and friends at home.

All grade six students preferred both English and Fante as medium of instruction. Whilst all grade four students preferred to learn mathematics generally in English, fractions in Fante and measurement in both English and Fante. Their Teacher (TX) preferred a mix of Fante and English (but more of English) as a medium of instruction, whilst the headteacher (HX) preferred teachers to use only English language as the medium of instruction.

The finding concerning thinking language showed that the majority (7 out of 8) of the students thought in Fante, only SX64 thought in both Fante and English.

The findings also showed that teachers make use of OOSM in ISM, however, whilst TX perceived the Ghanaian school language policy as affecting the use of OOSM in ISM, his headteacher (HX) perceived the Ghanaian school language policy as not affecting the use of OOSM in ISM.

The findings further brought to light that students bring forward cultural differences such as finger counting in mathematics lessons. However, the teacher rejects some of the cultural differences students bring with them from home to the mathematics lesson, such as the use of non-algorithmic approach to mathematics problem solving. The use of finger counting is also discouraged in school.

The school encourages collaboration between parents and teachers in students' mathematics transition although this is mainly in the form of the school making the parents aware of the needs of the students and also the teacher advising parents to supervise children's learning at home.

In the next section, findings from the School W (the school that prohibits parents' participation in students' mathematics learning) will be presented. This school is an above average achieving school (see Section 5.5.1.4). As with the schools C, L and X, findings from students' activities, as well as interviews with the headteacher and teachers concerning social and cultural influences on students' mathematics learning, and students' transition experiences between the home and the school will be presented.

6.4 School W

In this section the findings from School W will be presented. These involve findings from focus group interviews with 4 grade six and 4 grade four students, and findings from individual interviews with their teachers (Teacher W6 and TW4), and the school's headteacher (HW). Thus the interview results will be presented in Sections 6.4.1 to 6.4.6.

6.4.1 Children's Activities

In this section, the findings concerning how both grade four and grade six students experienced the concepts discussed in the introduction of Chapter Six at home and in the school contexts will be presented.

6.4.1.1 Students' activities at home: Identifying and comparing fractions.

Out-of-school task: Table 6.4.1 presents the findings from School W students' identification of a glass one-sixth full of water and a glass one-fifth full of water at home. Findings from Table 6.4.1 show that as with the students in School C, L and X, both grade six and four students in School W also had difficulty identifying unit fractions in the out-of-school task. Only SW42 was able to identify one-sixth (see Figure 6.4.1). None of the two sets of students was able to identify one-fifth. The results also revealed that students had weak conception about arithmetic fractions. SW61 for example explained why the content of Glass A1 is a quarter as because, "it is not up to the middle of the glass." The findings from Table 6.4.1 also show that the grade six students used same fraction names to identify the two sets of fractions.

Table 6.4.1. Identification of one-sixth and one-fifth by students from School W at home

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SW61	quarter	quarter
	SW62	quarter	quarter
	SW63	one over four	quarter
	SW64	quarter	quarter
Four	SW41	One-eight	One-sixth
	SW42	One-sixth [correct answer]	quarter
	SW43	One-half	quarter
	SW44	half	One-seventh

However, when the contents of the two glasses (A1 and B1) were presented to students to compare both grade six and four students identified the content of Glass B1 as being more than Glass A1. However, they did not revise their answers.

Grade four students' presentation

Glass A1 Glass B1

Figure 6.4.1. School W students' presentation of content of Glasses A1 and B1 at home.

Findings from School W students' identification of a glass half full of water and a glass three-fifths full of water at home are summarised in Table 6.4.2. The findings in Table 6.4.2 show that whilst both grade six and four students could correctly identify a half (content of Glass A1), neither the grade six students nor the grade four students were able to identify three-fifths (content of Glass B2). The findings confirm the earlier observation of students' weak conceptions about arithmetic fraction (see Table 6.4.1). SW42 for example explained why she identified the content of Glass B2 as one-eight as because, "it is up [ewo sor in Fante language.]", an indication of a guessed answer. Some of them also continued to use same fraction names for the two fractions (SW62).

Table 6.4.2. Identification of half and three-fifths by students from School W at home

Grade level	Student	Glass A2 (half)	Glass B2 (three-fifths)
Six	SW61	half	One-quarter
	SW62	half	One-half
	SW63	half	No verbal response
	SW64	half	One-quarter
Four	SW41	half	One- third
	SW42	half	One- eight
	SW43	half	One- third
	SW44	half	One -third

However, in comparing the contents of the two Glasses, all of grade six and four students identified the content of Glass B2 to be more than Glass A2. Meanwhile the majority (6 out of 8) of them used a smaller fraction name for Glass B2. The findings from out-of-school Task1 and Task II appear to show that students' notion of a half is not fixed; it could be at the midpoint (all grade four and six students) or above the midpoint (SW62), or even below the midpoint (SW44). In all the two out-of-school tasks relating to the identification of fraction (Task I and Task II), the most common fraction name that was used often by grade six students was a quarter (ten times). This was followed by a half (five times). The most common fraction name that was used often by grade four students was a half (seven times), followed by one-third (three times).

In- school task: The results from in-school task on fractions at home also showed that both grade six and four students had difficulty identifying fractions. As with the students in Schools C, L and W, they also tended to concentrate on the number of partitions in the whole and the shaded portion to decide on what fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole. For example, in identifying one-fifth, they counted five divisions and one shaded portion and presented their answers as one-fifth. They were able to identify one-sixth and one-fifth in the in-school Task1, and three-fifths in in-school task II, without problems. The two sets of students however had difficulty identifying a half (a fraction they were able to identify in the out-of-school task). This was because as with the students in Schools C, L and X, both grade six and four students could not easily figure out the number of divisions in the whole, as shown in the excerpts from interviews with grade six students below:

> **R**: ok continue with the next one [pointed at the first question in ii]
>
> **Students**: [looked closely at the question]
>
> **SW62**: [began to count the number of divisions silently, others looked on]
>
> **SW61**: two over quarter
>
> **SW63**: no, it is not two over quarter
>
> **SW61**: make it two and a half
>
> **SW64**: [write's the group's answer as two and a half, as shown in Figure 6.4.2.]

Grade four students identified half as three-sixths.

Grade six students’ presentation

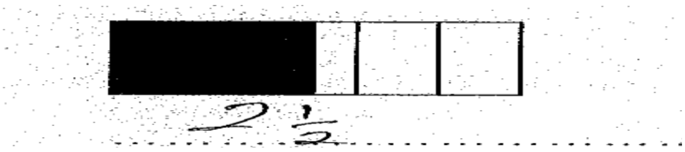
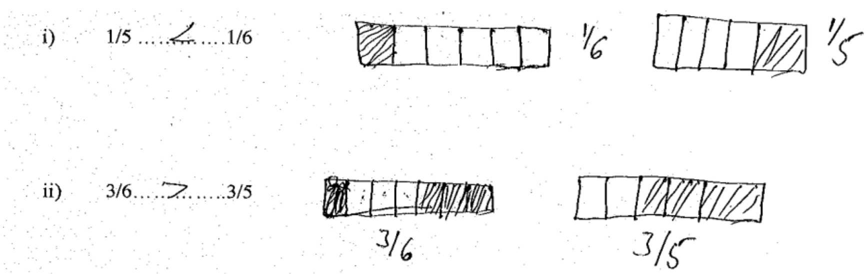


Figure 6.4.2. School W students’ presentation on identification of a half in-school Task II.

Students inability to identify a half indicates that like the grade six students in Schools C, L and X, their notion of part-whole relationship in fractions in school was also limited to number of shaded portion(s) divided by number of divisions, instead of relationship between the whole and the shaded portion of the whole.

In comparing fractions, both grade six and four students used the wrong symbols to compare the two sets of fractions. Whilst grade six students used wrong diagrams to justify their wrong answers (see Figure 6.4.3), grade four students could not justify their answer at all, “sir looking at one-fifth and one-sixth we think one-sixth is more” (SW41); “when we looked at the two we observed that three over five is not equal to three over six, so three over six is more” (SW43). It can be seen from Figure 6.4.3 that what grade six students have presented as one-fifth appears to have been divided into six. Also all the diagrams have been unequally divided, suggesting that division as far as these students are concerned does not necessary mean equal division.

Grade six students’ presentation



Grade four students' presentation

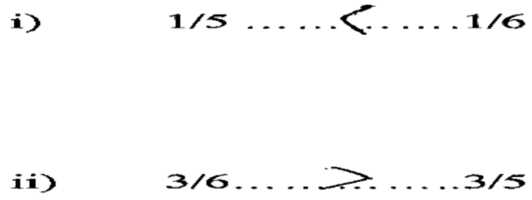


Figure 6.4.3. School W students' presentation on comparing fractions in in-school task at home.

6.4.1.2 Students' activities at home: Division of fractions/measurement of capacities.

Out-of-school task: As with students from C, X and grade six students in School L, both grade six and four students in school W approached their solution in the out-of-school task in an informal way, using an empty margarine tin. Both sets of students set three containers and went round each of these containers with a cup of maize, to find out what each person would get, before finding the total number of cups of maize through oral computation.

As with the grade six students in School C, SW64 used diagrams to present their correct answer (see Figure 6.4.4). Grade four students could not provide written presentation of their solution, as shown from the excerpts of interviews with grade four students below:

R: How did you arrive at your answer?

SW43: [explains in Fante] sir we shared it [maize] one, one, what was left we shared it half, half

SW41: sir, we put in one, one and each had three and a half cups

R: Write your solution

Students: [none of them volunteered to write, all shook their head to show they could not write.]

SW41: we cannot write

Grade four students' presentation

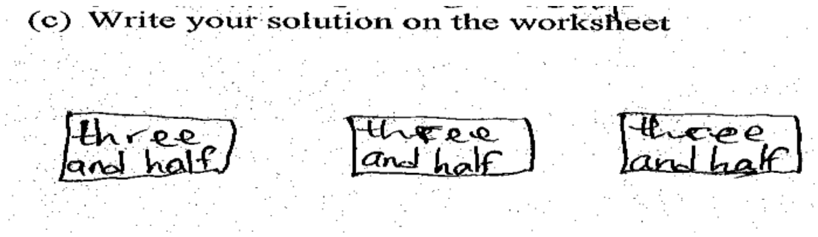


Figure 6.4.4. School W students' presentation of 10.5 divided by three in out-of-school task at home.

In-school task: As with the out-of-school task, both grade four and six students approached their solution to the in-school task in an informal way, using an empty margarine cup. Both sets of students followed the same procedure they used in sharing the maize in the out-of-school task to share the rice (see Section 6.4.1.2). As with the out-of-school task, they found what each person would get, before finding the total number of cups of rice as ten and a half through oral computation. SW64 again presented grade six students' solution in diagrams similar to Figure 6.4.4.

As with the out-of-school task, grade four students could not write down their solution at all. SW41 wrote only the total amount of rice and what each person had, but none could write their approach to the solution (see Figure 6.4.5).

Grade four students' presentation

2 (a) i) **How much rice is in the container?**

Answer: ..10 $\frac{1}{2}$..................................

ii) **Share the quantity of rice in 2(a) i) above equally among three people**

iii) **How much will each one of them get?**

......3 $\frac{1}{2}$..

Figure 6.4.5. School W students' approach to 10.5 divided by three in in-school task at home.

6.4.1.3 Students' activities at home: Multiplication of fractions/measurement of capacity.

Out-of-school Task: Both grade six and four students in School W also approached their solution to the word problem informally. However, the two sets of students differed in their approach to the problem. Grade six students called out their answer first and then provided oral computation to support their answer. They provided written presentation of their answer once they were requested to do so, as shown in the excerpts of the interviews below:

SW63: [orally say] nineteen and half

R: why is it nineteen and half

SW63: sir we are [sic] multiply three people by six and a half; three times six and a half will be

SW62: [continued] eighteen plus one and half will be nineteen and a half

SW64: [presents group's solution as shown in Figure 6.4.6]

Grade six students' presentation

We multiply 3 ~~pupils~~ peoples by 6 and half.

$\cancel{3 \times 6\frac{1}{2}}$ $3 \times 6 + \frac{1}{2} = 19$ & $\frac{1}{2}$

Figure 6.4.6. School W students' presentation of 6.5 times three in out-of-school task at home.

For grade four students, once the task was presented, SW43 counted his fingers and orally said, "nineteen and a half," the rest of the group members also said in chorus, "nineteen and a half". SW41 orally explained the group's solution in Fante, saying:

> we put that of two people together, and we had twelve [sic], and added that of the third person, and we had eighteen, and added one half to another to get one, and added one to eighteen to get nineteen, and we added half to get nineteen and a half. (SW41)

When the researcher requested SW41 to write down the solution, he wrote "$19\frac{1}{2}$", without showing any working.

In-school Task: Whilst grade six students approached the in-school task which involved 5.5kg times three also by using the informal approach (that is, going through oral computation before presenting their written solution, once they were requested to do so). Grade four students could not attempt the question at all.

Both sets of students had difficulty reading the word problem. The difficult words for the grade six students were "quantity," 'bought" and "whilst". Some of the difficult words/terms for the grade four students included "quantity" and "5.5kg" (which they read as 55kg). The grade four students read "quantity" as "quinty". The grade four students indicated that they did not understand "quantity"; they also indicated that they did not understand the question.

In solving the word problem in the focus group interview, SW62 said it is, “five point five times three; five times three is fifteen, plus one and a half, is sixteen and a half.” However, unlike the out-of-school task, SW64 presented group’s solution this time using a mathematical equation involving multiplication, as shown in Figure 6.4.7.

Grade six students’ presentation

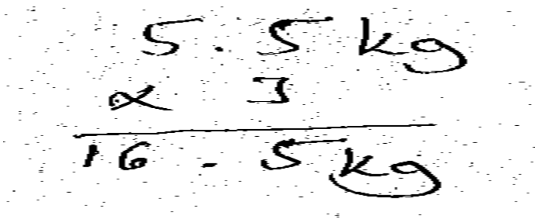


Figure 6.4.7. School W students’ presentation of 5.5 times 3 in out-of-school task at home.

6.4.1.4 Students’ activities at home: Addition of fractions and measurement of area.

Out-of-school task: Using the same approach as grade six students in Schools C and L, grade six and four students in School W measured four “poles” and then guessed the remaining area. This was evident from the excerpts from interviews with grade six students below:

> **R**: How many “poles” are there in the farm?
>
> **Students**: [chorus] Four and quarter
>
> **R**: Why is the remaining quarter?
>
> **SW63**: [explains in Fante] sir, what is left is neither a half nor one “pole” so it is a quarter; it is a fraction of a half [half ne nkyekyemu]

Evidence of guessed work could also be seen from SW42 and SW44 reason for saying four and a half as because, “when we measured some was left.” (SW42). And SW41 and SW43 reason for saying four and a quarter as because, “when we measured some was left, and what was left was not up to a half, it must be a quarter." (SW43)

In-school task: Both grade six and four students were able to read, and figure out the word problem as involving addition of fractions. Both sets of students were also able to come out with the correct answer as three-quarters, as shown in Figure 6.4.8. However, grade four students presented only the answer without mathematical equation. SW43, who verbalised the answer as three-quarters provided oral explanation as, "I added one to two to get three, and there were two fours so I took one of them."

Grade six students' presentation

$$\frac{1}{4}+\frac{2}{4}=\frac{3}{4}$$

Grade four students' presentation

3. (a) Papa Kojo gave Abena ¼ of an orange and Ekua 2/4 of an orange. How much orange did Papa Kojo give to Abena and Ekua altogether? $\frac{3}{4}$

$\frac{3}{4}$

Figure 6.4.8. School W students' presentation of solution to two-quarters plus a quarter at home.

Also, students were able to solve the problem involving the area of a rectangle in the in-school task. In solving the in-school task which involved finding the area of 2cm by 3.5cm rectangle, SW62 read the question without problems, after which SW64 wrote 3.5 times 2, without any formula, as shown in Figure 6.4.9.

Grade six students' presentation

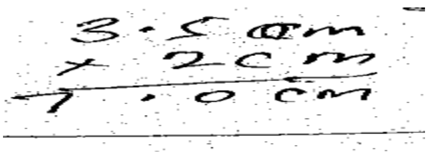


Figure 6.4.9. School W students' presentation of solution to the area of 2cm by 3.5cm rectangle at home.

In Sections 6.4.1.5 to 6.4.1.8, the findings from students' activities in school will be presented. The tasks students went through in school were the same task they were given at home. Students' activities in school therefore covered four areas, namely identifying and comparing fractions, division of fractions/measurement of capacities, multiplication of fractions/measurement of capacity, and addition of fractions and measurement of area (see Section 6). Findings from students' activities in school are presented below.

6.4.1.5 Students' activities in School: Identifying and comparing fractions.

Out-of-school task: Table 6.4.3 presents the findings from School W students' identification of a glass one-sixth full of water and a glass one-fifth full of water in school. Results from Table 6.4.3 confirm the earlier observation that both grade six and four students had difficulty identifying unit fractions (see Section 6.4.1.1). None of the two groups of students was able to identify one-sixth and one-fifth in Task I in the focus group interview. All grade six students continued to use the same fraction name to describe the two sets of fractions, whilst half of the grade four students did the same. Student SW44, for example, identified the content of Glass B1 as two-eights because, "it is a bit up", indicating that she did not understand what she was saying.

Table 6.4.3. Identification of one-sixth and one-fifth by students from School W in school

Grade level	Student	Glass A1 (one-sixth)	Glass B1 (one-fifth)
Six	SW61	quarter	quarter
	SW62	quarter	quarter
	SW63	quarter	quarter
	SW64	quarter	quarter
Four	SW41	one-eight	one-eight
	SW42	one-eight	one-eight
	SW43	one-tenth	one-eight
	SW44	one-eight	two-eights

However, when students were asked to compare the contents of the two glasses (A1 and B1), all grade four and six students identified the content of Glass B1 to be more than Glass A1.

Presented in Table 6.4.4 is the findings from School W students' identification of a glass half full of water and a glass three-fifths full of water in school. The findings from Table 6.4.4 show that like the out-of-school activity at home, all grades six and four students were able to identify a half in Glass A2. As with the students in schools C, L and X, none of the grade six and four students was able to identify three-fifths in Glass B2. SW62 explained a half and a quarter in the local language as, "mfinfin na kakra [midpoint and a little]." SW61 explained "half quarter" as, "half and a little." SW42 identified the content of Glass B2 as two-eights because, "it is more [owo sor kese, in Fante language]." Whilst SW44 identified it as one-eight because, "it is more than the other [referring to the content of Glass A2]." Some of the students continued to use the same fraction names to identify the two sets of fractions (SW63 and SW64).

Table 6.4.4. Identification of a half and three-fifths by students from School W in School

Grade level	Student	Glass A2 (a half)	Glass B2 (three-fifths)
Six	SW61	half	half quarter
	SW62	half	half and a quarter
	SW63	half	half
	SW64	half	half
Four	SW41	half	six-eighths
	SW42	half	two-eights
	SW43	half	six-eighths
	SW44	half	one-eight

In comparing the contents of the two glasses, however, all grade four and six students identified the content of Glass B2 as being more than Glass A2. The fraction names that were used often by the grade six students in Task I and Task II were a quarter (eight times) and a half (six times). The most common fraction names that were used often by grade four students were "one-eighth" (seven times), followed by a half (four times).

In-school-task: Findings from in-school task on fractions in school also showed that both grade six and four students had difficulty identifying fractions. As with the students in School C, L and X, both the grade six and four students in School W also tended to concentrate on the number of partitions in the whole and the shaded portion to decide on what fractions they were dealing with, rather than looking at the shaded portion in relationship to the whole. They were therefore able to identify one-sixth and one-fifth in the in-school Task1, without problems. In Task II also, they were able to identify three-fifths, but as with the School C students, both the grade six and four students rather identified a half as two and half out of five (see Figure 6.4.10).

Grade six students’ presentation

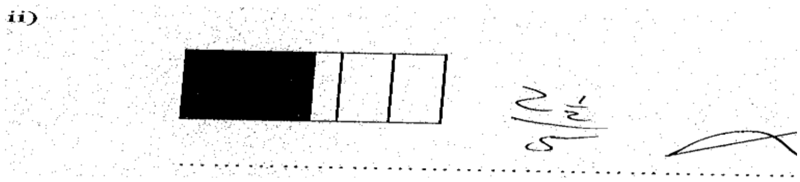


Figure 6.4.10. School W students’ presentation on identification of a half in-school Task II in school.

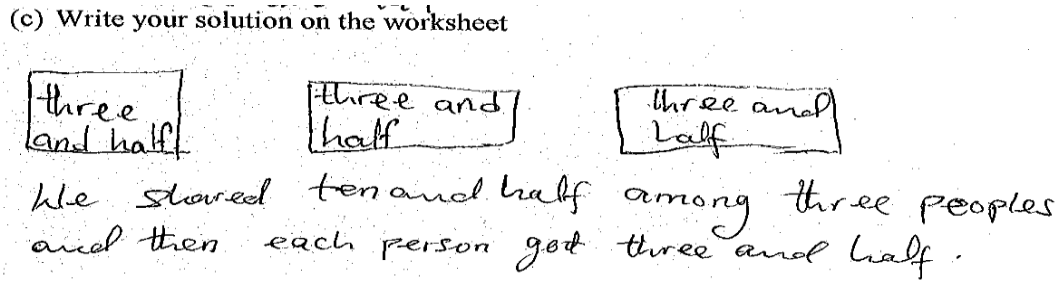
Both sets of students’ inability to link two and half out of five to half confirms the earlier observation (see Section 6.4.3.1) that their notion of part-whole relationship in fractions seems to be limited to number of shaded portions divided by number of divisions, instead of relationship between the whole and the shaded portion in the whole. This also shows that students appeared to experience the concept of fractions differently in the real life situation in out-of-school task, and paper pencil activities in in-school task (that is, the criteria for part-whole relationship appears to change from one context to another).

As with the in-school activities at home (see Section 6.4.1.1), none of the grade six and four students could use the symbols to compare any of the two sets of fractions correctly. Grade six students indicated that one-sixth was greater than one-fifth because, “one over six is bigger than one over five.” (SW62) They also identified three-sixths to be more than three-fifths because, “three over six is bigger than three over five” (SW61). Grade four students also gave similar reasons.

6.4.1.6 Students' activities in School: Division of fractions/measurement of capacities.

Out-of-school Task: As with the activities at home (see Section 6.4.1.2), both the grade six and four students approached their solution to 10.5 divided by three in an informal way, using an empty margarine tin. As usual, both sets of students found what each person would get (three and a half cups), before they found the total number of cups of maize as ten and a half cups through oral computation. Unlike the out-of-school activities at home, grade six students used both diagrams and words to present their written solution, whilst the grade four students also used a mathematical equation to present their solution (see Figure 6.4.11).

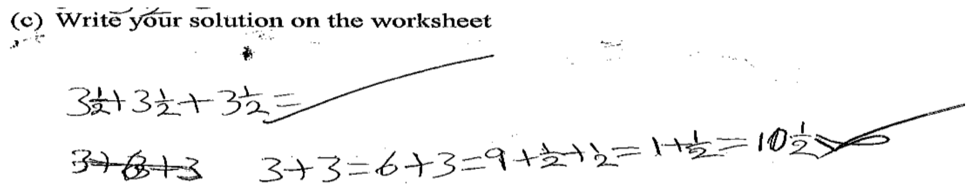
Grade six students' presentation


(c) Write your solution on the worksheet

three and half | three and half | three and half

We shared ten and half among three peoples and then each person got three and half.

Grade four students' presentation


(c) Write your solution on the worksheet

$3\frac{1}{2}+3\frac{1}{2}+3\frac{1}{2}=$

~~3+3+3~~ $3+3=6+3=9+\frac{1}{2}+\frac{1}{2}=1+\frac{1}{2}=10\frac{1}{2}$

Figure 6.4.11. School W students' presentation of 10.5 divided by 3 in out-of-school task in school.

In-school Task: As with the out-of-school task, both grade six and four students approached their solution to the problem in an informal way. They requested a margarine cup (as a unit of measure) and went round each of the three containers with a margarine cup of rice to find what each of them would get. They found the total number of cups of rice through oral computation.

As with the out-of-school activities, student SW64 drew three rectangles and wrote three and a half in each to show what each of the three had (similar to grade six students' presentation in Figure 6.4.11). When the researcher requested students to explain their solution SW64 said, "sir, see the drawing [referring to a drawing similar to Figure 6.4.11]."

Unlike the activities at home where grade four students provided no mathematical equation (see Section 6.4.1.2), in the presentation of their solution in school, a mathematical equation was used to justify their solution, as shown in the excerpts of the interviews below:

> **R**: Write your solution on the worksheet
>
> **Students**: [orally say in chorus] "three plus three equal to six, plus three, equals to nine. Half plus half equal to ten [sic], plus half equals to ten and half."
>
> **SW41**: [presented the group's solution using a mathematical equation, as shown in Figure 6.4.12.]

Grade four students' presentation

ii) Share the quantity of rice in 2(a) i) above equally among three people

$3+3=6+3=9+\frac{1}{2}+\frac{1}{2}=10\frac{1}{2}$

The approach is ~~wrong to~~ right but they have missed and addition of $\frac{1}{2}$

iii) How much will each one of them get?

$3\frac{1}{2}$ ……………………………………………………………………

Figure 6.4.12. School W students' presentation of 10.5 divided by three in out-of-school task in school.

It could be observed from Figure 6.4.12 that SW41 left out a half but still ended up with the correct answer as ten and a half. This is an indication that they worked towards the answer.

6.4.1.7 Students' activities in School: Multiplication of fractions/measurement of capacity.

Out-of-school Task: As with the out-of-school task at home, both grade six and four students used an informal approach to solve this question. Both sets of students verbalised their answer as, "nineteen and a half" (SW63, SW43). For grade six students, SW62 orally explained the group's answer of nineteen and a half saying, "six times three plus one and a half will give us nineteen and a half." SW62 presented the group's written solution as "$6x3+\frac{1}{2}$ = 19 and $\frac{1}{2}$."

Unlike the out-of-school activities at home where grade four students did not use any mathematical equation (see Section 6.4.1.3), in this activity the grade four students used mathematical equations. SW43 presented the group's solution using repeated addition (see Figure 6.4.13).

Grade four students' presentation

$$6+6=12+6=18+\frac{1}{2}+\frac{1}{2}=1+\frac{1}{2}=19\frac{1}{2}$$

Figure 6.4.13. School W students' presentation of 6.5 times three in out-of-school task in school.

In-school Task: Grade six students solved the word problem involving 5.5kg times 3 without problems. SW61 read the question, whilst SW62 wrote the correct mathematical equation as 5.5kg times 3, and solved it to arrive at the correct answer of 16.5kg (similar to Figure 6.4.7).

As with the activities at home, grade four students had difficulty reading the word problem. The difficult words/terms were “5.5kg”, “quantity” and “whilst”. They could not figure out the demands of the question. SW41 explained the demands of the question saying, “the question says we should add 55 and three...” He orally called out the answer as “fifty eight.” SW43 presented the group’s solution as “55+3=58”.

6.4.1.8 Students’ activities in School: Addition of fractions and measurement of area.

Out-of-school task: As with their activities at home, both grade six and four students measured four “poles” and guessed the remaining part. However, grade six students were divided over what their final answer should be. After measuring four “poles”, SW62 said, “sir four and half poles,” whilst SW61, SW63 andSW64 said, “four and quarter”. SW64 attempted to explain their answer saying, “what is left [the remaining part] is not up to one “pole”,” “it is neither a half “pole”” (SW63). The group settled on four and a quarter “poles”, so SW63 presented the group’s solution in prose as, “four and quater [sic].”

Unlike the activities at home where grade four students differed in opinion over what the area of the citrus farm was, in school, all of them said the area was four and a half. SW41 presented the group’s solution as, “$4\frac{1}{2}$”.

In-school task: Both grade six and four students were able to read, and solve correctly, the word problem involving the addition of two quarters to a quarter. For the grade six students, SW64 presented the group’s solution as shown in Figure 6.4.14. Grade four students verbalised their answer in chorus as three-quarters. SW43 presented the group’s solution as shown in Figure 6.4.14. The results from grade four students activity in school appear to show that context (school) affected the way they approached mathematical problem solving. They made use of mathematical equations in the activities that were carried out in the school's premises as compared to the activities that were carried out at home.

Grade six students' presentation

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$$

Grade four students' presentation

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$$

Figure 6.4.14. School W students' presentation of answer to a quarter plus two quarters in in-school task in school.

As with the in-school activities at home, grade six students found the area of 3.5cm by 2cm rectangle, as 7cm, instead of 7cm^2. SW63 presented the group's solution as 3.5cm times 2cm equals 7.0cm (that is, similar to Figure 6.4.9 above).

Grade six students used the local language in communicating amongst themselves during the out-of-school activities. They used both English and Fante in communicating amongst themselves during the in-school activities. SW63 andSW61 indicated that they thought in English language and Fante, "sir [referring to the researcher] English and Fante" (SW61). SW62 said he thought in Fante, whilst SW64 said he thought in English. SW64 explained further saying, "sir when I am thinking I think in Fante but when I am writing I write in English." SW64's explanation shows that he rather thinks in Fante, but not English.

Grade four students used the local language in communicating amongst themselves in all the activities. All grade four students indicated they used Fante in thinking.

SW43 and SW41 explained further saying, “sir we read the text in English, and use Fante to think about it” (SW43), “then we use English to write our answer.” (SW41)

6.4.2 Students’ Perceptions

6.4.2.1 Students’ perceptions about mathematics

Interviews with grade six students showed that as with the grade six students from schools C, L and X, they also had culture-related perceptions about mathematics. With the exception of “a kente/twil weaver” which all students identified as a person who does not use mathematics, they identified all others including “a local market woman selling rice” as somebody who uses mathematics. All grade four students identified “a driver’s mate” and “a butcher” as people who do not use mathematics. They were also not sure whether “a Kente/twil weaver” uses mathematics or not. They, however, identified “a farmer” and “a local market woman selling rice” as people who use mathematics.

However, both sets of students perceived OOSM and ISM as different, “sir they are different” (SW64); “they are different,” (chorus, grade four students) “home mathematics we don’t write, but the school mathematics we use pen or pencil to write.” (SW43)

The majority (3 out of 4) of the grade six students perceived both OOSM and ISM as equally important, “both are important; Kilogrammes [ISM] sometimes we cannot do it but ‘Olonka’ [OOSM] I can do it” (SW63), only SW64 perceived ISM to be more important than OOSM because, “Kilogrammes is always in mathematics, ‘Olonka’ comes in once a while” (SW64). SW63 and SW64 would want to study only ISM because, “we know ‘Olonka’ already, but we do not understand Kilogramme, so we want to learn more” (SW64). SW61 and SW62 would want to study both because, “teacher occasionally uses some [OOSM]...” (SW62). Unlike the grade six students, all the grade four students valued ISM more than OOSM, “school mathematics is more important,” (SW43) because, “that is what we need for our future; we will need it if we want to become teachers," (SW41) "it[school mathematics] helps us to progress." (SW42)

The grade six students associated OOSM with traders, "traders use 'home' maths" (SW63), and farmers, "farmers also use it" (SW64). They associated ISM with the educated, "those who go to school" (SW64); "those who work in office." (SW63) As with the students in School L, the grade four students also associated OOSM with women, "our mothers at home use them [OOSM]." (SW43) They associated ISM with, "school children and teachers" (SW41).

6.4.2.2 Students' perceptions about parents' knowledge.

Grade six students indicated that their parents' mathematical practices are different from what they study in school, "she sells so she teaches ... how to measure, as we did here in the activities [using empty margarine tin]." (SW63). For the grade four students SW42 and SW43 indicated that their mothers' mathematical practices are different from what they experience in school, whilst the rest of them indicated their parents' mathematical practices are not different from ISM.

Both grade six and four students however appeared to value their parents' mathematical knowledge. Some of the typical explanation they gave included, "she sells so that helps her to keep her money well" (SW62). SW64 thought some of his illiterate mother's mathematics practices are similar to what he studies in school, "at times what she teaches us at home is similar to what we learn in school." SW41 said "they [parents' mathematical practices] are good." However, SW62 thought the illiterate mother does not teach any meaningful mathematics, "sir, my mother was not educated so when I go to her she doesn't teach me anything meaningful, except my dad [who is educated]."

6.4.3 Language Use and Preference

6.4.3.1 Students' language use and preference.

Findings from interviews with both grade six and four students showed that English language appears to be the language for the classroom. Both sets of students said they use Fante in communicating with their parents and friends at home, because, "we don't understand English." (SW41)

However, in school, language use differed amongst the grade six and four students. Grade six students said they use English with the teacher and their friends in class when there is a lesson. All of them said they use English in communicating with the teacher when there is no lesson, and during break time. All of them said they use Fante in communicating with friends when there is no lesson. They said they use the same language (Fante) in communicating with their friends during break time.

Grade four students said they use English in communicating with their teacher when there is a lesson, and Fante with their Friends. According the students, they use Fante to communicate with the teacher and their friends when there is no lesson, and also during break time.

Interviews with grade six students also showed students as saying their teacher uses mainly English in teaching mathematics, and "sometimes when we are having difficulty understanding, he uses Fante" (SW62). Students indicated that their teacher uses English and Fante in teaching fractions and measurement. The findings further showed all grade four students as saying their teacher uses English in teaching mathematics generally, and measurement and fractions specifically.

Both grade six and grade four students said they prefer to study mathematics generally in English because, "… when the headteacher comes to talk to us in English we would also be able to use English to answer him."(SW64); "... we don't understand English, that is why we prefer English" (SW41), "sir, by so doing we will be learning it [English]" (SW43).

The two sets of students however differed in their language preference by topics. Grade six students preferred to study fractions in Fante because, "... fractions are very difficult, when he is teaching and we don't understand we want him to use Fante to explain it to us, so that we can understand what he is saying." (SW62) Also, all of them preferred to study measurement in English and Fante because, "some of the measurements are very easy and others are difficult." (SW62) All grade four students preferred to learn fractions and measurement also in English, "in order to understand English." (SW42)

6.4.3.2 Teacher's language use and preference.

Findings from interviews with the grade six and four teachers in School W (TW6 and TW4) showed both of them as saying students use both Fante and English in class when there is mathematics lesson, "combination of Fante and English...," (TW6) "both Fante and English." (TW4) The findings further showed TW6 as saying the students use Fante when there is no lesson, and also when they are outside the classroom during break. TW4, however, said students use both the Fante and English language when there is no lesson in class, and when they are outside during break time, "sometimes English and sometimes Ghanaian language [Fante]". Interviews with TW6 and TW4 further revealed TW6 as saying he uses, "combination of English and Fante" in teaching mathematics generally, and fractions specifically, for two reasons. Firstly to, "help pupils to contribute to the lesson," and secondly, "some of the topics pupils know already are in Fante... the relevant previous knowledge of the pupils will help me to teach the lesson better." TW4 said she uses, "English, since it [mathematics] is written in English." TW4 said, "when it comes to fractions I use English" because:

> the RPK [relevant previous knowledge] of pupils is that they already know how to share, ... you involve pupils to share one-third, meaning

> three people are going to share one whole thing, they would be able to divide, instead of using the Fante over and over again. (TW4)

TW6 said he uses English in teaching measurement because, “in measurement the units are all in English and it is hard for me to translate into Fante.” Whereas TW4 said, “I use English, and at times I use Fante because some of the pupils in the class may not understand some of the concepts in measurement.” TW6 said he usually uses English to communicate with children when there is no lesson, “because I want my pupils to learn the language [English].” Whereas TW4 said she uses, “English and Ghanaian language, because some cannot express themselves in English, so when you speak English to them they speak Fante to you.”

Both TW6 and TW4 said they use both English language and Fante in communicating with children during break time, “combination of English and Fante,” (TW6) “both English and Fante.” (TW4) They said they use both English and Fante because, “the pupils find the English language difficult in expressing themselves, so I give them the free will to communicate with me in Fante for them to be able to express themselves,” (TW6) “I want to prompt them that they should always speak the Queens language, because we were colonised by the British, and we are using it [English] as the medium of instruction in school.” (TW4)

Both TW6 and TW4 said they use Fante in communicating with students outside the school premise, “most of the times I communicate with them in Fante,” (TW6) “I speak Fante with them.” (TW4) TW6 speaks Fante with students because, “English is a problem for them to speak..., in town I don’t feel like bothering them very much with the English language.” (TW6) TW4 speaks Fante with students, “for the pupils to be able to express themselves or for them to be able to approach you whenever they see you, that is why I speak Ghanaian language [Fante] with them.”

Both teachers would prefer students to use English language in mathematics lessons because:

> I want my pupils to speak the English language, and use them in their everyday activities. The assessment is based on English language, so I don't want my pupils to have any difficulty in answering questions, which are being set in English language. (TW6)

TW6 would prefer to teach fractions and measurement in English because, "their syllabus is in English, and their textbooks are also in English, and the language for instruction in school is English, the units of measurement are in English." The findings further showed TW4 as saying, "well in class four, English language is the medium, so I prefer using the English, but in case I have difficulty for pupils to participate in the class, I would try to chip in Ghanaian language." (TW4) TW4 explained further saying:

> sometimes when you say do you understand? They would say yes madam, but when you ask them in the L1 [Fante] "hom atse ase a [have you understood]", they would say no they didn't understand. It means they did not get the concept, unless you bring it back to their level [in Fante]... (TW4)

TW4 prefers to use English in teaching fractions because, "pupils already have the knowledge of sharing and division..." She, however, prefers to use English and the Fante in teaching measurement because, "pupils have seen other people using measurement with kerosene and water [sic]..."

6.4.3.3 Headteacher's language use and preference.

According to the headteacher of School W (HW), teachers use, "… both English and Fante at the lower primary. At the upper primary they use English, but occasionally they go in with Fante," when there is a mathematics lesson. HW also said the students' use English during mathematics lessons. However, they use, "... both Fante and English language when there is no lesson in class." The findings also revealed HW as saying students mainly use the local language during break time, "I usually hear them speaking Fante." Unlike the students and the teachers (TW6 and TW4), HW would prefer teachers to use, "both English and Fante, for proper understanding of the subject."

6.4.4 The use of OOSM in ISM

6.4.4.1 Policy influences.

Interviews with Teachers W6 and W4 (TW6 and TW4), indicated that both of them appeared not to be aware of the language policy of Ghana, which requires the use of Ghanaian language at the lower primary and English language from the upper primary. "It says teaching should be done in the English language at the upper primary and the junior secondary school. For the lower primary I don't know much," (TW6) "it says that we must use the English language as the medium of instruction in the upper primary (that is from class four to six), and [at] the lower primary it is the L2 [English] and L1[local language]." (TW4)

TW6 and TW4 differed in opinion on the influence of the language policy on the use of OOSM in ISM. According to TW6:

> it doesn't affect the use of out-of-school mathematics in my lesson, in the sense that what the pupils know already are all in the local language, therefore, when they come to the classroom, it is a matter of giving the English language for them to know what those things are about.

TW4, however, said that the language policy affects the use of OOSM in ISM, "yes, it does ... I use the Ghanaian language when I am teaching mathematics, the sciences and other subjects, because there are certain concepts that you should let the pupils participate. You shouldn't always do the talking ..."

Interviews with headteacher of School W (HW) indicated that unlike the teachers from his school, he was aware of the language policy of Ghana, “at the lower primary they use the Fante language, whilst from class four up to class six it is the English language. However, it is not a fix thing. I mean you just consider the standard of the children.” HW thinks the language policy of Ghana has no effect on the inclusion of OOSM in ISM:

> I don’t see any problem with it, since I am saying both languages help the child to understand the lesson and solve problems. As I said, the children are more conversant with their local language. They understand when they learn from the house, so it is like building on what the children already know, using their own language. They know “Fa ka ho [add],” “yi bi fir mu [take away],” “kye [divide],” and so on and so forth. (HW)

6.4.4.2 Classroom practices.

Results from interviews with Teachers W6 and W4 (TW6 and TW4) showed both of them as saying students make use of their out-of-school experiences in measurement in school mathematics, “yes, they make use of it” (TW6). TW6 explained further saying, “they try to apply the out-of-school local units of measurement, in the sense that when it comes to measurement the pupils try to bring what they know already at the house ...” TW4 also explained saying, “in the home they know how to measure with the milk tins and other tins even when they are playing, so we try to build on what they already know by adding more...” However, TW4 believes, “they must always make sure that whatever they learn in class they would apply, but rather, they shouldn’t apply what they know from the market to the classroom.” According TW6, students’ out-of-school knowledge on measurement interferes their learning:

> it interferes the learning, because they would not get the basic units of measurements ... Where the unit is below they try to round it up to fit a small unit; for example, when you have ‘four point two’ they would say four, not to get confused with the two digit [zero point two], and when it is ‘four point nine’ they would say five. (TW6)

Interviews with TW6 and TW4 further showed that students do not make use of their out-of-school knowledge in sharing, in the classroom, “sometimes they [students] get motivated, they already know how to share, they are eager to learn, but they would find out that how they share at home is not how they are going to share in school ...,”(TW4) “it[out-of-school knowledge in sharing] doesn’t support their learning, because they would always be forced to learn the wrong thing.” (TW6)

Interviews with headteacher of School W (HW) showed him as saying teachers make use of OOSM in ISM through role-play:

> they usually use the role-play in their teaching, like buying and selling, which children they know right from the home. And even there are various games in the house, which deals with counting, with subtraction. We have a game like “whewhe mu beyi wo dzi,” where they form a circle, and they go round and then you have somebody to touch, all those you touch would have to leave [the game]. They would be leaving and leaving until they are all finished, this leads to the concept of counting. (HW)

HW also perceived the use of OOSM in ISM as bringing understanding between the school and the community, “when they go to the house they interact with their parents, they even work with it [OOSM] in the society. It brings understanding between the school and the community.” (HW)

6.4.5 Cultural Differences Students Bring Up in Mathematics Lessons

Both Teacher W6 and Teacher W4 (TW6 and TW6) mentioned unequal sharing, and out-of-school notions in measurement as some of the cultural difference students usually bring forward in mathematics lessons. This was also evident in the way the students partitioned wholes, in the identification of fractions in students’ activities (see Section 6.4.1.1). According TW6:

> they bring the culture from the house to the classroom, because the relevant previous knowledge that they have on mathematics come from the house, so they bring those ideas in the classroom ..., example is like things of sharing. Sharing is under mathematics as fractions. In sharing always the eldest take the bigger share.

In measurement TW6 said, “I give them measurement of paper strip they tend to add their own thing to round it up, like what is being done outside the school.”

TW4 explained how students bring out-of-school cultural notions in sharing in mathematics lessons, saying:

> let’s take that the thing is one whole, like a loaf of bread, call three pupils to come and share it under the topic of the thirds. You will find out that they would not be able to share it equally; one person may think I am the eldest and others may think I am also grown, so they would not be able to share it equally...

As with the teachers from schools C and L, both TW6 and TW4 appear to handle cultural difference by concentrating on the school’s way of doing mathematics, “I try to help them to put aside culture from the house and learn the one in the school, because assessment would be based on what is learnt in the school, but not what is learnt in the house.” (TW6) In measurement TW6 explained, “I don’t give them the chance to measure the way they do at home, but I give them what it means to measure in the classroom.”

TW4 explained:

> Fractions in the class means equal parts, sharing things equally, so that you make them understand that what they share at home when their mother is sharing food, using their ages or how they are matured ... when we come to school whether you are old, big, or small, we are sharing things equally, into equal parts.

TW6 handles the cultural difference by concentrating on the school’s way of doing mathematics, “just to get my pupils aware of formal education.” (TW6) Analysis of TW6’s marking of students’ worksheet showed that he sometimes rejects non-algorithmic way of solving problem. This was evident in TW6 outright rejection of students’ presentation of how they solved 10.5 divided by 3, as shown in Figure 6.4.15.

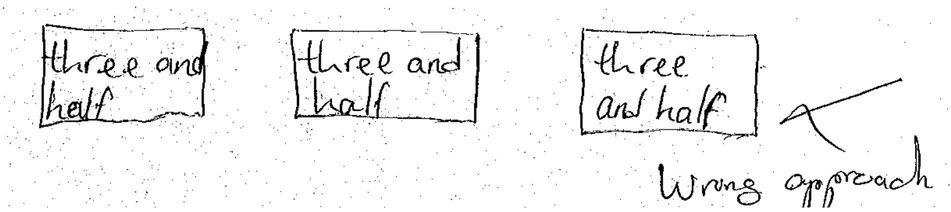


Figure 6.4.15. TW6’s marking of students’ activities involving 10.5 divided by three.

Analysis of TW4’s marking of students’ worksheet showed that she rather appeared to accept the use of OOSM in school. This was evident in TW4’s acceptance of students’ use of non-algorithmic method in solving the problem involving 6.5 times three, as shown in Figure 6.4.16.

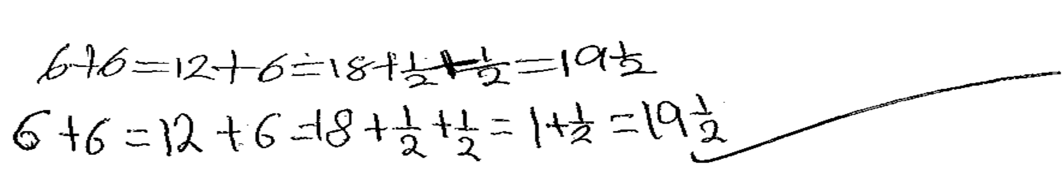


Figure 6.4.16. TW4’s marking of students’ activities involving 10.5 divided by 3.

Interviews with headteacher of School W (HW) showed HW as saying he did not see any cultural differences from the mathematical experiences students bring with them from home, but it rather helps:

> let say when you are teaching measurement, the child may even be selling, so the moment they talk about measurement she gets it. She has the concepts in mind. In fact from my orientation, I don't see any conflict, it rather helps the child to understand the new things they are going to learn. (HW)

6.4.6 Parents' and Teachers' Collaboration in Students' Mathematics Learning in School

Interviews with TW6 and TW4 showed both of them as saying they do not collaborate with parents in students' mathematics learning, "not at all," (TW6) "not really." (TW4) TW6 does not collaborate with parents because:

> ... I don't get adequate time to find out about pupils activities, also because of financial resources; because I need to board a car. Also the parents will not give their maximum cooperation, because they think you are coming for the weakness of their children, to punish them, so they would not be willing to give you the correct information on their children. Most of the parents are illiterate, so they would not get the knowledge to help the children to study mathematics. (TW6)

TW6 explained further:

> ... most of the parents are illiterate, when you give them the information they cannot help their children to solve mathematics problems. Their knowledge is informal but in the school we deal with the formal knowledge. So the informal and the formal cannot meet, that is why.

TW4 does not collaborate with parents in students' mathematics transitions because, "what we teach in school is solely for the children ..." However, TW4 finds out why students do not do their homework from parents:

> sometimes I tell the pupils to tell their parents that the teacher would want to see him/her, so that when they come I try to find out from them what they [students] normally do at home that make them not able to do their homework.

According TW4 she contacts parents, "when we [the teachers] evaluate our lessons, assignment and others and we get to know that they [students] are not performing or they do not do the assignment at all"

The second interviews (stage two) with HW confirmed that the school does not usually encourage parents' and teachers' collaboration in students' mathematics transition (see Section 5.5), HW explained further:

> the whole thing is that the teachers have been trained to teach the children, and they follow let say a pattern from the curriculum. Here I think they are aware of what they teach, they know what they are going to teach and what they expect the children to know. In a way, let's say, they prepare for what they are going to teach.

According to HW, the school does not encourage parents' and teachers' collaboration because, "parents, in a way, may not be aware of the concept they are imparting to the children." (HW)

6.4.7 Summary of the Results from School W

In Section 6.4 findings from students' activities as well as interviews with grade four and six teachers, and headteacher in School W were presented. The findings from students' activities on fractions showed that students had difficulty identifying unit fractions in the real life situation. As in schools C, L and X, students identified a half easily in the real life situation in the out-of-school tasks, but not the other fractions (one-sixths, one-fifths and three-sixths). However, they had difficulty identifying a half in the paper and pencil activity in the in-school task. They also used the same fraction name to identify different fractions. Thus their notion of unit fractions was not fixed. The most common fraction names that were used throughout the activities on the identification of fractions in the real life situation were a half, a quarter and one-eight. Their notion of fractions in school was also limited to the number of shaded portions divided by the number of partitions in the whole.

Both grade six and four students approached measurement informally, using an empty margarine tin as a unit of measure in all contexts. Context tended to affect students' approach to problem solving differently. Whilst grade six students used informal approach once the problem was a practical one and formal approach once it was a paper and pencil type, the grade four students used mathematical equations to solve all activities that were carried out in the school premises but used no mathematical equation in activities that were carried out at home.

Students approached division as a repeated subtraction in the problem solving. However, unlike the students from the other schools, multiplication was approached as a product. Grade four students' had difficulty reading and understanding questions involving word problem.

The findings concerning students' perceptions about mathematics showed that students generally had culture-related perceptions about mathematics (especially grade six students). The students' schema of persons who use 'mathematics' in their work they do included "a local market woman selling rice" and "a farmer" but not "a Kente/Twil weaver." They perceived OOSM and ISM as different. Grade four students valued ISM more than OOSM, whilst grade six students perceived the two as equally important. They associated ISM with the educated, and OOSM with women. They also saw some worth in parents' mathematical practices, despite the fact that the majority (6 out of 8) of the students' perceived their parents' mathematical practices as being different from school mathematics.

The findings on language use indicated that English is mainly used in the classroom during lessons. TW4 said she uses English in teaching mathematics generally and fractions specifically, whilst TW6 said he uses both English and Fante in teaching mathematics generally and fractions in particular. However, TW6 uses only English in teaching measurement, whilst TW4 said she uses English and a bit of Fante in teaching measurement. However, all students said they use Fante in communicating with their parents and friends at home.

Both teachers preferred their students to use English language in class. All students and their teachers preferred the use of English as a medium of instruction in mathematics generally. However, grade six students preferred to learn fraction in the local language, for a better understanding, whilst TW4 also preferred to use both Fante and English in teaching measurement. Unlike the teachers and the students, HW rather preferred teachers to use both English language and Fante in teaching mathematics, for a better understanding of the subject.

The finding concerning students' thinking language showed that the majority (7 out of 8) of the students as saying they thought in Fante. Only student SW61 thought in both Fante and English.

Responses on the use of OOSM in ISM indicated that teachers make use of OOSM in ISM in this school. However, whilst HW and TW6 perceived the Ghanaian school language policy as not influencing the use of OOSM in ISM, TW4 thought otherwise. Interviews with the teachers further showed that they generally reject cultural differences which do not support ISM. They concentrate on the school's way of doing mathematics, when students bring forward cultural differences. The teachers also said they generally do not collaborate with parents to help students' mathematics transitions.

6.5 Summary of the Findings from the Four Focus Schools

In this chapter findings from interviews with students, their teachers and headteachers, and analysis of documents from the four focus schools were presented. The analysis of the results across the focus schools on the identification of fractions showed that students could identify a half in the real life situation but they had difficulty identifying the same fraction in the paper and pencil activities in the in-school task. The same fraction names were used to identify different fractions across the four focus schools. Students' notion of arithmetic fractions was not fixed. Their notion of part-whole relationship in fractions in school was limited to the number of shaded portions divided by the number of partitions in the whole, instead of the relationship between the shaded portion of the whole and the whole.

Division was approached as repeated subtraction in all the four focus schools. Whilst grade six students from all the focus schools shared equally in task involving fractions as division, grade four students from School C and School X did not think of sharing between people as involving equal sharing. Multiplication was approached mainly as repeated addition in problem solving. Students' from half of the schools were able to add fractions and also measure the area of a rectangle using local activities but they could not add fractions and find the area of rectangle in the paper and pencil task in the in-school activities. Addition of mixed numbers was approached using the decomposition method. Measuring of capacity was approached in all the school types mainly using an empty margarine tins.

A common approach the students used in problem solving involved verbalisation of their answers, followed by oral computation and then written presentation of their results, either in prose or using mathematical equations. Also, students had culture-related perceptions about mathematics. They identified OOSM and ISM as being different. They generally associated ISM with the educated and OOSM with the people such as farmers and traders, ISM was also more important to students than OOSM.

Even though English served as a barrier to the students' understanding of word problem solving (especially the grade four students), the findings showed that it is widely used in class during mathematics lessons. The English language also remained the language all teachers would prefer their students to use in class.

The majority (26 out of 32) of students from all the focus schools would prefer to study mathematics in English, very few (2 out of 32) of them preferred to learn mathematics in Fante. Teachers from half of the schools preferred to teach mathematics in English, only one teacher (TL4) preferred to teach mathematics generally in Fante. Half of the headteachers would prefer teachers to use English whilst the remaining half would prefer them to use both English and the local language.

Teachers and their headteachers from all the focus schools (including those from School L which discourage the use of OOSM in ISM) said teachers make use of OOSM in ISM. With the exception of the headteacher from School W, all teachers, including teachers from School W and their headteachers said students bring forward one form of cultural difference or another during mathematics learning. Some of the cultural differences that were mentioned included unequal sharing (in fraction as division), rounding of whole in measurement and oral presentation of mathematical procedures.

However, the findings from the interviews and analysis of documents indicated that the teachers generally rejected cultural differences that were perceived as not supporting ISM. The majority (5 out of 6) of the teachers perceived the Ghanaian language policy as affecting the use of OOSM in ISM. However, the majority (3 out of 4) of the headteachers thought otherwise (did not perceive the Ghanaian language policy as affecting the use of OOSM in ISM).

The findings concerning parents' and teachers' collaboration in students' mathematics transition across the four focus schools showed that half (3 out of 6) of the teachers collaborate with parents. The remaining half did not collaborate with parents. The finding also brought to light that with the exception of School X, where the teacher said he collaborates with parents' of high achieving students, parents' and teachers' collaboration in students' mathematics transition becomes necessary when students have problems especially with school mathematics.

In the next chapter, there will be the detailed discussions of the results from the questionnaire survey on headteachers' and teachers' perception of mathematics presented in Chapter five, and the findings from all the four focus schools presented in this chapter. These results from Chapters five and six will be synthesised to address each of the research issues and questions that were posed in Section 2.4. Thus the discussion of results presented in Chapters five and six will be presented in the next chapter.

Chapter Seven - Discussion

In this chapter discussion of the results presented in Chapters Five and Six will be provided. This will throw light on how social and cultural influences mainly from school affect students' mathematics learning. Also discussed will be some of the student participants' transition experiences between the home and school, and how their knowledge of OOSM influences their conceptions and practices in school. The discussion will therefore be provided in two main sections based on the two research issues, namely 1) what are the sociocultural influences on Ghanaian students' mathematics learning? 2) What are Ghanaian children's transition experiences between the home and the school contexts and how do these affect their learning in school? Whilst in Chapter Six the results were presented based on individual schools in the four focus schools, the structure of presentation in this chapter will vary. Discussion of the results will be done across the four focus schools in relationship with the research questions. This will enable the researcher to explore the similarities and the differences in the research participants' responses across the four schools. This will provide broader pictures as well as special cases from the results presented in Chapters Five and Six. Thus the discussions in this Chapter will involve the general situation across all schools, and unique situations among the cases.

7.1 Social and Cultural Influences on Students' Mathematics Learning

In this section social and cultural influences from the school such as exposure to school mathematical culture (as in ISM; see Chapter two section 2.3), language use and preferences, and influences of teachers' and headteachers' perceptions of mathematics on students' perceptions will be discussed. This will throw light on how some of these social and cultural influences may be impacting on students' mathematical conceptions and practices in the school.

7.1.1 Perception of Mathematics

As already noted in Chapter three, culture-related perceptions in this study refers to perceptions that take cognisance of mathematics in the out-of-school setting, whilst culture-free perceptions are perceptions that do not recognise mathematics as a cultural object. Also school mathematics culture refers to the culture of the use of international/western mathematics which dominate the school curriculum (ISM), whilst out-of-school mathematical culture refers to the culture of everyday or out-of-school cultural notions in mathematics within Ghanaian society (OOSM), (see Sections 2.1 &2.3). Once Ghanaian students go to school they experience mainly school mathematics since OOSM has virtually no place in the school curriculum (see Section 2.1.1). Once they leave the school premises they experience predominantly OOSM, since that is mainly the mathematics in the environment (see GNA, May 2009a). For the purpose of easy comparison of students' perceptions and headteachers' and teachers' perceptions of mathematics, this section will be presented in two parts. Students' perception of mathematics will be presented in Section 7.1.1.1 whilst the headteachers' and teachers' perceptions of mathematics will be presented in Section 7.1.1.2.

7.1.1.1 Students' perception of mathematics.

A study of the findings concerning students' perceptions about mathematics across the four focus schools shows that they generally had culture-related perceptions about mathematics. With the exception of grade four students from School W, who identified a relatively smaller number of pictures as people who use mathematics (see Section 6.4.2), the rest of the students identified most of the pictures as people who use mathematics (see Sections 6.1.2, 6.2.2 & 6.3.2). Students' notion about mathematics generally was not limited to ISM but included OOSM as well. However, all students from the four focus schools identified OOSM as being different from ISM. In School W, for instance, the grade four students said in chorus; "they are different", "home maths we don't write but school maths we write with either pencil or pen" (SW43). They also identified the two sets of mathematics as being unrelated in some cases (see Section 6.1.2.1).

The students’ observation about ISM being different to OOSM confirms the situation in the Ghanaian setting where one set of mathematics is practised at home and another set in school (as already noted in Section 2.3). The quote from SC42; “we use Kilogrammes in school and margarine cup at home” (see Section 6.1.2.1), shows that this student is aware that the two sets of mathematics are practised in different contexts. They appear to be aware that the language for the two sets of mathematics is also different. A look at a quote from SC62 for example; “school mathematics is studied in English but home mathematics is different” (see Section 6.1.2.1) confirms this. Students appear to be also aware that ISM is the written mathematics, “home maths we don’t write but school maths we write with either pencil or pen” (SW43). Thus the students appear to know some of the differences between the two sets of mathematics. It is therefore not surprising to the researcher that students identified the two sets of mathematics as being different and unrelated in some cases, as OOSM is virtually excluded from the school curriculum.

With the exception of grade six students from School W where the majority (3 out of 4) of the students identified OOSM and ISM as equally important, and grade four students from School C where half (2 out of 4) of them identified ISM and OOSM as equally important, all students identified ISM as being more important than OOSM. Some of the reasons they gave included “that is what we need for our future…” (SW41; see Section 6.4.2.1), which shows how the dominance of ISM in the school mathematics curriculum appears to affect students’ perception about mathematics (see Section 2.1.1; Anamuah-Mensah, Anamuah-Mensah & Asabere-Ameyaw, 2009). Others reasons such as “we know ‘Olonka’ already but we do not understand Kilogramme, so we want to learn more” (SX64; Section 6.3.2.1), show the difficulties some of these students face in learning measurement in school. Students appear to be aware that the successful progression of a student through the formal education ladder in Ghana depends on the mastery of ISM but not OOSM per se. It is therefore likely for the students to attach more importance to ISM than OOSM since at the end of the day they would be tested on ISM.

The students across the four focus schools also generally associated ISM with students and the educated, and OOSM with the uneducated and people in the informal sector of the economy such as traders (see Sections 6.4.2.1 for example). Those in the informal sector of the economy in Ghana are predominately illiterates. Some students across the four focus schools also associated OOSM with women (see Sections 6.2.2.1, 6.3.2.1 & 6.4.2.1). In School L for instance SL43 said “it is good for women because they sell” (see Section 6.2.2.1). OOSM is associated with women because the informal sector of the economy in Ghana is dominated by women, the majority of whom have very low or no educational background (see UNESCO, 2009 for example). Thus women dominate the informal sector of the economy in Ghana where OOSM also dominates. It is therefore not surprising to the researcher that some of these students associated OOSM with women’s knowledge.

These findings add to a body of literature on valorisation in mathematics education, which highlights that students value mathematics that exists in school more than mathematics that exists out-side school (Abreu, 1993, 1995). Also students generally identified more with in-school mathematical culture. This was also evident in some of the students’ responses such as “those who go to school,” (SW63) “school children like us” (SX42), “Students” (SL44), when they were requested to indicate which group(s) of people in their society are associated with school mathematics.

Students’ perceptions about OOSM and ISM in the school with the most culture-related views about mathematics pedagogy (School X) were not different from those from School L, which was identified as the school with the most culture-free view about mathematics pedagogy. Both sets of students exhibited culture-related perceptions about mathematics (see Sections 6.2.2.1 & 6.3.2.1). Both sets of students also identified ISM as being different from OOSM; all grade six students in School X for instance said “they don’t look alike” whilst grade six students in School L also said “they don’t look alike.” Both sets of students valued ISM more than OOSM; “we use school mathematics for examination, if you don’t learn it you will fail” (SX62). Discussions on students’ perceptions about their parents’ mathematical knowledge will be presented in the rest of this section.

With the exception of School W, where half of the students said their parents mathematics practices are not different from school (see Section 6.3.3), all students said their parents' mathematical practices are different from the school. In School X for instance SX63 said "they know only home mathematics…" (see Section 6.3.2.2). This depicts the general situation in Ghana as the students themselves, teachers, politicians, researchers and the whole of Ghanaian society at large engage in the use of OOSM once they are at home or on the street. The literature suggests that Ghanaians reject the use of measuring scales in the local market (GNA, May 2009a), indicating that the SI unit has little or no place in the out-of-school setting. Also politicians even quote the prices of commodities using the local unit of measure (see GNA, May 2009b). It is therefore natural for the majority of the students to see their parents' mathematical practices as being different from school practices.

Students, however, generally valued their parents' mathematical practices, probably because they appear to appreciate the OOSM as what seems to operate mainly in Ghanaian society. Statements from students such as "they don't know mathematics" (SX63, SX61); "they know only home mathematics …" (SX63) suggest that some of these students do not only see ISM as being more important than OOSM but also as the 'authentic' mathematics. This is because, if knowing "home mathematics" means not knowing mathematics, then "home mathematics" is not the 'authentic' mathematics.

The researcher will turn now to the discussion on headteachers' and teachers' perceptions about mathematics, to help ascertain how similar/different they are from those of the students.

7.1.1.2 Headteachers' and teachers' perception of mathematics.

Headteachers' and teachers' perceptions about mathematics comprise four areas of perceptions, namely perceptions about mathematical knowledge, perceptions about mathematics pedagogy, perceptions about links between Ghanaian culture and mathematical knowledge and perceptions about the link between Ghanaian culture and mathematics pedagogy (see Section 3.3.1.1). Both the headteachers and the teachers had similar perceptions about mathematics (see Chapter Five). Headteachers generally had culture-free perceptions about mathematical knowledge. The majority (8 out of 10) of the items in the headteachers' questionnaire received culture-free responses. They generally perceived mathematical knowledge as being certain (19 out of 24), mathematical truth as being fixed (16 out of 24), and mathematical truth as being unquestionable (16 out of 24) (see Chapter Five Table 5.1a). About half (11 out of 24) of them saw mathematics as calculation. However the minority (5 out 24) of them exhibited an open view about mathematics. An example was H24, who saw mathematics as the "reaction of human mind to his/her environment in terms of weight, time, space and so on." They generally perceived mathematical knowledge as a universal knowledge which is the same everywhere (as already noted in Chapter Five).

As with the headteachers, the teachers also had culture-free perceptions about mathematical knowledge. The majority (8 out of 10) of the teachers' questionnaire items also received culture-free responses (see Table 5.2b). As with the headteachers, the teachers also perceived mathematical knowledge as universal knowledge, which is the same everywhere. T22's perception about mathematical knowledge sums up how culture-free some of these teachers' perceptions of mathematics were; "… mathematics is the same everywhere, there is no difference in home mathematics and school mathematics" (T22; Section 5.2.3).

The headteachers' perceptions about mathematics pedagogy were also not culture-related as a big minority (3 out of 9) of the items in the headteachers' questionnaires had culture-free responses. More than half (14 out of 24) of the headteachers perceived success in mathematics as depending on the intellectual ability of the learner. The same number also perceived learning mathematics as requiring mainly memorising facts. As with the headteachers, the teachers' perceptions about mathematics pedagogy were also not culture-related, as a substantial minority (4 out of 9) of the items in the teachers' questionnaire received culture-free responses. More than half (96 out of 137) of the teachers also perceived success in mathematics as being dependent on the intellectual ability of the learner, whilst half (69 out of 137) also perceived the learning of mathematics as basically requiring memorising facts.

From the discussion of the first two components of headteachers and teachers perceptions about mathematics it is evident that the two had similar perceptions about mathematics and mathematics pedagogy. It is possible that because the headteachers were once teachers they are likely to share similar perceptions with the teachers. This is because the position of a headteacher in the Ghanaian school system is more of a reward for those who stay in the teaching for a long period of time.

The dominance of ISM in the Ghanaian school curriculum, coupled with its associated learning theories which do not recognise cultures of learners and teachers, could contribute to the culture-free perceptions of headteachers and teachers to mathematics and mathematics pedagogy (see Section 2.1.1; Anamuah-Mensah, Anamuah-Mensah & Asabere-Ameyaw, 2009). Headteachers' and teachers' universal view of mathematical knowledge could not only be explained by the trends in the internationalisation of mathematics education but it could also be historical. This is because the fact that Ghanaian students in the past stayed in Ghana and followed the Cambridge mathematics curriculum and wrote the Cambridge examinations may convey the notion that mathematical knowledge is universal (see Davis & Ampiah, 2005). Also the fact that the school mathematics curriculum captures mainly ISM and leaves out the numerous OOSM's in Ghanaian society may give the teachers and headteachers the impression that ISM is the 'authentic' mathematics. This is reflected in TL6's statement in Section 6.2.5:

> In the home parents do not teach them [children] *actual mathematics* [the researcher's emphasis] it is oral work but when you come to the school, classroom work it is always written lesson so children would have to solve things mathematically not saying it orally...

Thus in TL6’s view the “actual mathematics” is the mathematics that is encountered in school but not in the home. Also, to some of these teachers the appropriate pedagogies are those that go with the “actual mathematics”:

> we try to let them know that what they know in the market is right, that is out of school but when they come to school they should try to get what we are doing because that one is written, ... (TW4)

Despite headteachers’ and teachers’ culture-free perceptions about mathematical knowledge and their perceptions that mathematics pedagogy is not culture-related both groups appreciated the links between Ghanaian culture and mathematical knowledge, and also between Ghanaian culture and mathematics pedagogy.

The analysis of headteachers’ responses to items relating to the links between culture and mathematics knowledge showed that only a few (2 out of 9) of the items received culture-free responses, three out of nine of the items received culture-related responses, with the remaining four receiving responses that suggested trends toward culture-related conceptions about the links between Ghanaian culture and mathematical knowledge. The majority (19 out of 24) of them perceived mathematics as having some relevance to indigenous communities. Overwhelming majority (22 out of 24) of them indicated that activities carried out in society generate mathematics. This implies that they generally seemed to be open to other forms of mathematics apart from ISM. The majority of the headteachers perceived counting (83%) and measuring (79%) as activities that generate mathematics. However, almost half (45.8%) of them did not see designing as activities that generate mathematics, whereas a big minority (37.5%) did not see playing as an activity that generates mathematics.

As with the headteachers, analysis of teachers’ responses to items relating to links between Ghanaian culture and mathematics knowledge also revealed that only a few (2out of 9) of the items in the teachers’ questionnaires received culture-free responses. Almost half (5 out of 9) of the items received culture-related responses, with the remaining two receiving a trend towards culture-related responses. As with the headteachers, the majority (111 out of 137) of the teachers also perceived indigenous cultural practices as having a place in mathematics. A vast majority (126 out 137) of them also indicated that activities carried out in Ghanaian society could generate mathematics which may not be the same as the school mathematics. This is an indication that, like the headteachers, the teachers also recognised mathematical practices in the society as a form of mathematics.

Like the headteachers, the majority of the teachers also perceived counting (84.6%) and measuring (74.5%) as activities that could generate mathematics. Surprisingly almost half (48.9%) of teachers did not see playing as an activity that generates mathematics, whilst more than half (56.9%) of them did not see designing as an activity that generates mathematics. However, these two activities are amongst some of the most culturally rich mathematical activities in the Ghanaian culture that literature on mathematics in the African contexts often cites (see; Anamuah-Mensah, Anamuah-Mensah & Asabere-Ameyaw, 2009; Gerdes, 1988, 1999; Zaslavsky, 1973).

Even though some of the headteachers did not see any link between the Ghanaian culture and mathematics pedagogy; “Mathematics education has nothing to do with culture” (H21; Section 5.1.4), the vast majority of them perceived some links between the two. None of the items received a culture-free response, 10 out of 12 of the items received culture-related responses, whilst the remaining two received a response which showed trends towards culture-related perceptions about the links between the Ghanaian culture and mathematics pedagogy.

The majority (22 out of 24) of the headteachers perceived one’s cultural practices as having a place in mathematics pedagogy. Measurement was the topic most (87.5%) of the headteachers perceived as allowing for the inclusion of out-of-school mathematical practices. Interestingly, operation on numbers was the topic that the majority (66.3%) of the headteachers did not see as allowing for the inclusion of out-of-school mathematical practices (see Table 5.1f).

Like the headteachers, the teachers also perceived some links between Ghanaian culture and mathematics pedagogy. None of the twelve items on the links between culture and mathematics pedagogy in the teachers' questionnaires received culture-free responses. The majority (10 out of 12) of the items received culture-related response, with the remaining two receiving responses which showed trends toward culture-related perceptions about links between the Ghanaian culture and mathematics pedagogy.

The majority (115 out of 137) of the teachers also perceived one's cultural practices as having a place in mathematics pedagogy. Measurement was the topic most (75%) of teachers perceived as allowing for the inclusion of out-of-school mathematical practices. Interestingly, operation on numbers was the topic that the majority (66.3%) of them did not see as allowing for the inclusion of out-of-school mathematical practices (see Table 5.2f). This has implications for the teaching of operations on numbers.

The discussion so far on headteachers' and teachers' perceptions about links between the Ghanaian culture and mathematical knowledge, and links between Ghanaian culture and mathematics pedagogy shows that both had similar culture-related perceptions. It is evident from the discussion that both headteachers and teachers perceived ISM as the "authentic" mathematics but they rather appreciated some links between ISM and Ghanaian culture.

There is some connection between headteachers' and teachers' perceptions about mathematics, and students' perceptions about mathematics. It is evident from the discussion so far that children's perceptions about mathematics may have been influenced by the school (particularly by the teachers). The children's perception about the difference between ISM and OOSM for instance reflects headteachers' and teachers' universal view about mathematics. Their notion of ISM being more important than OOSM also reflects teachers' view of ISM as the "authentic" mathematics, and also the political support for ISM in the school curriculum.

Thus, from the discussion so far in this section, it is evident that even though the research participants perceived ISM as the "authentic/important" mathematics, they generally perceived OOSM also as a form of mathematics. ISM was viewed as "authentic/important" mainly because it is the mathematics in the school curriculum and it is also examinable. OOSM was also seen as a form of mathematics, probably because some of the dominant mathematical practices involving measurement and fractions especially in the out-of-school setting are mainly in the form of OOSM. It is therefore not surprising to the researcher that students valued OOSM and teachers found links between mathematics pedagogy and Ghanaian culture.

Language plays a vital role in mathematics classroom discourse; it is the medium through which students are instructed, it is also the medium through which students think, communicate their ideas and are tested (see Section 2.2.3). For political reasons the English language has remained the only official language in Ghana and has continued to remain the official language of instruction in Ghanaian schools (mainly from grade 4 onwards) since Ghana's independence (see MOESS, 2008). Thus, unlike many other non-western countries, a person's progression in the academic ladder in Ghana is very much dependent on that person's mastery of the English language. In the next section discussion of results on students' and teachers' language use and preference across the four focus schools that was presented in Chapter Six, Sections 6.1.3, 6.2.3, 6.3.3 and 6.4.3 will be provided.

7.1.2 Preference for Language of Instruction

As with the research participants' perceptions of mathematics, for the purpose of easy comparison of students' language preference and headteachers' and teachers' language preference, this section will be presented in two sections. Students' preference for language of instructions will be presented in Section 7.1.2.1 whilst the headteachers' and teachers' preferences will be presented in Section 7.1.2.2. Discussions on language preference are preceded by a brief discussion on language use within and outside school premises generally, and the language of mathematics. This is to help explore the relationship between language preference and the language use in schools.

7.1.2.1 Students' preference for language of instruction.

A look at students' language use across the four schools showed that English language appeared to be the language of school. Out of the 32 students who participated in the focus group interviews (see Chapter Three) only one of them (SC41) said that she speaks English with the parents at home. All the rest said they speak Fante with both their parents and friends at home. A look at some of the reasons some of the students gave in support of their reasons why they use Fante at home such as "some friends don't go to school" (SX63), "this helps us to converse" (SX64), "they [referring to parents] like Fante" (see Section 6.3.3.1) appears to suggest that the home environment of some of these student participants did not encourage the use of English outside the school premises. Other reasons such as "we do not understand English" (SW41) also suggest that some of the students may be struggling with the English language.

Results on students' language use within the school premises across the four focus schools revealed all students as saying they use English in communicating mainly with teachers in class during lessons. Interviews with teachers confirmed students' use of English language during mathematics lessons (see Section 6.1.3.2 for example), however some of the teachers indicated students' use of both the English language and Fante (TL6: Section 6.2.3.2).

The language students said they usually use in the classroom when there are no lessons (no teaching is going on) varied across schools and grade levels. In schools C and X for instance whilst grade six students said they use English in class whether or not there are lessons, grade four students said they use English with the teacher alone and Fante with friends when there are no lessons. In School W (which is an above average achieving school) both sets of students said they use Fante to communicate with friends and English with the teacher. In School L both sets of students said they use English in communicating with both teachers and friends when there is no lesson.

The findings from students in School L (a rather low achieving school) rather create the impression that they have no chance to communicate in Fante in class. According these students they usually pay a fine for speaking the Fante; “in class five we had to pay 500 Cedis [AUD 40 cent] for speaking Fante” (SL64; Section 6.2.3.1). This finding reminds the researcher of his experience as a year seven student in Ghana where students who disturbed the class using the local language were given double punishments, one for disturbing the class and two for using the local language. Students who disturbed the class using English language were given only one punishment for disturbing the class.

None of the students from the four focus school said they use Fante in communicating with the teacher in class. However gaps appear to exist between what some teachers said and what the students said. With the exception of TX and TW4, who said students use a mix of English and Fante when there is no lessons (which confirmed students’ results), all teachers said students use Fante when there is no lesson. The responses from the teachers were also confirmed by those of their headteachers about the language the students use when there is no lesson. Headteachers from schools X and W said students use a mix of English and Fante when there is no lesson, whereas the remaining headteachers (HL and HC) said students use Fante in class when there is no lesson.

Language use during break time also varied across the schools and grade levels. Grade six students from schools L, W and X said they usually speak English with their teachers and Fante with friends during break time. It appears from some of the students' explanation that they speak English with teacher to avoid embarrassment, "when you speak Fante with the teacher he would ask you to leave his presence" (SX64), "he would cane you before he asks you to leave" (SX63; see Section 6.3.3.1). Only grade six students from School C said they usually use English in communicating with both their friends and teachers to avoid punishment. With the exception of grade four students from School C who said they use Fante with their friends and English with their teachers, mainly to avoid embarrassment; "if you speak Fante she would say speak English" (SC41; see Section 6.1.3.1), all grade four students said they use Fante in communicating with both teachers and students during break time (see Sections 6.2.3.1, 6.3.3.1 & 6.4.3.1). This implies English language use outside class appears to be stricter with grade six students than grade four students in some schools. Interviews with teachers showed half of them (TC, TW4 and TX) confirming the use of both the English language and the local language during break time. The remaining half (TW6, TL4 and TL6) also confirmed the use of the local language during break time. However all headteachers said students use the local language during break time. It is evident from the result that in some schools it is an offence for students to speak the local language with their teacher in school.

The results of language of instruction for mathematics from students also varied across the four focus schools. Half of the students from the four focus schools (schools L and C) said teachers use only English in teaching mathematics generally and fractions and measurement specifically. In school X for instance students said that the teacher uses a mix of Fante and English in teaching mathematics generally. However whilst grade six students said TX (who teaches mathematics at both levels, see Section 6.3.3.1) uses only English in teaching fractions, all grade four students said he uses both Fante and English in teaching fractions and measurement. This seems to show that TX's choice of language of instruction in mathematics depends on the topic and the level at which he is teaching. In School W, whilst grade six students indicated that their teacher uses mainly English but switches to Fante if they have difficulty understanding, grade four students indicated that their teacher uses

English in teaching mathematics generally and measurement and fractions specifically. This also appears to show that teachers' use of language of instruction in mathematics depends also on the teacher. Students' language preference, which is the main focus of this section, will be discussed in the rest of the section.

With the exception of grade six students from School X who preferred to learn mathematics generally in English and Fante (see Section 6.3.3.1), almost all students (including grade four students) from the four focus schools said they preferred to learn mathematics generally in the English language. Only 2 out of 32 students (SC43 and SL41) from the eight focus groups said they preferred to learn mathematics in Fante. SC43's (a lower achiever) reason for his preference for Fante as the language of instruction in mathematics ("I don't understand lessons in English", SC43) may help to throw light on a possible reason why he might have been branded as such.

With the exception of grade six students in School C who said they preferred to study mathematics in English because English is the language of examinations (see Section 6.1.3.1) and grade six students from School L who preferred to study mathematics in English because their teacher is not fluent in the Fante language (see Section 6.2.3.1), all other students preferred to learn mathematics in the English language because they either want to learn English; eg "we don't understand English that is why we prefer English… " (SW41), or because they want to learn to communicate well in English; eg "we want to speak English" (SL42) (see Section 6.2.3.1), "we want the English so that we can speak English …" (SX61).The response of Grade four students in School W as to why they prefer to learn measurement and fractions in English ("in order to understand English") may summarise the main reason why the majority of the students may prefer to learn mathematics in English. Thus some of these students prefer to learn mathematics in English not necessarily to understand or enjoy the learning of mathematics in English but to gain an additional advantage of learning the English language.

Students’ preference for the English language as their preferred language of instruction in mathematics is surprising to the researcher, as one would hardly expect students to opt to study mathematics in their weakest language. One would have expected most students (especially all grade four students) to say they preferred Fante (which is their strongest language) since English was a barrier in the solution of word problems (especially in the in-school Task IV). In this task both students who had the concept of multiplication of decimals (see Sections 6.1.1.7 and 6.2.1.7; Figure 6.1.14) and those who did not have this concept (see Sections 6.3.1.7 and 6.4.1.7) could not interpret the demands of the question correctly. It appears the importance of English language in the Ghanaian school system seems to influence students’ language preference. SC41’s reason for her preference for English as the language of instruction as “Fante wouldn’t take us anywhere except English” (see Section 6.1.3.1) confirms this. Students appear to be aware that they need to be stronger in the language of the test in order to succeed (Howie, 2002; Tsang, 1988).

However, students’ language preference for mathematics generally differed from their language preference for the various topics (i.e. measurement and fractions) in some cases (see Section 6.2.1.1 for example). Students’ language preference by topics varied across the four focus schools, and across grade levels. Grade six students in schools C and L for instance preferred to study fractions and measurement in English whilst grade six students in School X preferred to study fraction and measurement in both the English language and Fante (see Sections 6.1.3.1, 6.2.3.1 and 6.3.3.1).

Also, whilst grade six students in schools C and L preferred to study fractions and measurement in English, half of grade four students (high achievers) in School C preferred to study both fractions and measurement in the English language, whereas the remaining half (lower achievers) preferred to study fractions and measurement in Fante. All grade four students in School L preferred to study fractions in Fante whilst the majority (3out of 4) would want to study measurement in Fante (see Section 6.1.3.1 and 6.2.3.1).

Students' preference for the language in mathematics rather depended on their perceptions of the difficulty of topics in some cases (see Sections 6.2.3.1; 6.4.3.1; for example). Grade six students in School W, for instance, preferred to study fractions in Fante because "fractions are very difficult…" (SW62; Section 6.4.3.1), all grade six students in the same school rather preferred to study measurement in both English language and Fante because; "some of the measurements are very easy and others are difficult" (SW62; Section 6.4.3.1). Some students preferred to study fractions in Fante for better understanding; "for everybody to understand" (SL42; Section 6.2.3.1).

This shows that students appear to be aware that they can learn mathematics better in Fante but their language preferences appear to be influenced by their future needs for examinations, since progression from one level in the academic ladder to another depends on scores in examinations (which are conducted in the English language but not Fante). It is evident from the discussion so far on students' language preference that the majority (30 out of 32) of the students' preference for language of instruction in mathematics rather reflects the language of schooling (which is English).

In the next section headteachers and teachers' language preferences will be discussed to help ascertain how similar/different they are from those of the students.

7.1.2.2. Headteachers' and teachers' preference for language of instruction.

Results from the teachers showed that teachers' language use in school varied across the four focus schools. All teachers from half of the schools (C and L) said they use English language whether there are lessons or not. They said they use the same language outside the classroom during break time. A third (TX and TW4) of the teachers from two schools (X and W) said they use both English and Fante whether there are lessons or not. Only TW6 said he uses both English and Fante when there is a lesson and only English with students when there is no lesson. All teachers from schools W and X said they use both English language and Fante outside the classroom during break time.

All headteachers however indicated that teachers use mainly English language at the upper primary level (grades 4-6). However, it was evident from some of the headteachers' responses that the Ghanaian language is usually employed in some cases as a resource to aid students understanding of concepts (see Section 6.1.3.3 for example).

With the exception of TX, who said he speaks both English and Fante with the students outside the school premises, all the teachers said they speak Fante with the students outside the school premises. Some of the reasons the teachers gave in support of their use of Fante with the students outside the school premises included; "English is a problem; I don't feel like bothering them" (TW6; Section 6.4.3.2). This confirms the earlier observation that the English language appears to be a language of school.

All teachers said they use mainly the English language in teaching mathematics. The majority (4 out of 6) of the teachers said they use only the English language in teaching mathematics generally (see sections 6.1.3.2, 6.2.3.2and 6.4.3.2). The remaining two (TW6 and TX) said they use mainly English but a bit of Fante as well (see sections 6.4.3.2 and 6.3.3.2). This finding is similar to those of Setati (2003) as well as Setati, Adler, Reed and Bapoo (2002) who found dominance of the English language in multilingual classroom environment in South Africa.

Results from language use by topics, however, varied across schools and teachers. All teachers from half of the schools (schools C and L) said they use the English language in teaching both fractions and measurement. TX said he uses mainly English language and a bit of Fante to teach both fractions and measurement. However the use of language of instruction by the teachers in School W (above average achieving school) appears to depend on topics. Grade six teacher (TW6) said he uses both the English language and Fante in teaching fractions and only the English language in teaching measurement because of the difficulty in translating technical terms in measurement. TW4 said she uses the English language in teaching fractions because the students know terms like divide in English, but uses both the English language and Fante in teaching measurement for all students to understand the lesson. This implies that teacher participants from the majority (3 out of 4) of the focus schools said they use the same language in teaching mathematics generally, and measurement and fractions specifically. These results confirm the earlier observation from students' results that the English language is mainly used in teaching mathematics.

All teachers preferred their students to use English language in their mathematics class, mainly because the school mathematics curriculum is delivered in English. With the exception of TW6 who said he wanted his students to speak English and apply it to their everyday life, the rest of the teachers gave reasons such as "because it is the medium of instruction" (TX), "assessment is in English" (TW6), "word problems is in English" (TC, TL6) and "mathematics is written in English" (TL4) in support of their preference for the use of the English language by students.

Teachers' preference for language of instruction however varied across the schools. All teachers from half of the schools (schools C and W) preferred to teach mathematics generally in the English Language, because the syllabus is in English, textbooks are in English, medium of instruction is English (TC) and assessment is in English (TW6), (see sections 6.1.3.2 and 6.4.3.2). Whilst TX preferred to teach mathematics in both the English language and Fante (but more of English) because "English is the approved medium of instruction" (TX), TL6 preferred to teach mathematics in both the English language and Fante because "not all children can express themselves well in the English language."(TL6) Only TL4 preferred to teach mathematics in Fante because "that would make the children understand better..." (TL4).

The results from teachers' language preference showed that like the students, the majority of the teachers also preferred the use of English as a medium of instruction. This finding is surprising to the researcher, especially as TW6 for instance said that he did not want to bother students with English outside the school premises because English was a problem. Like TL4, one would have expected TW6 to say that he preferred the students to study mathematics in their strongest language (Fante) but not their weakest language (English language). However TW6's and his other colleagues reasons for wanting the use of the English language as the medium of instruction, such as because the assessment is in English, is somehow justified, because at the end of the day both the teacher's performance, and for that matter the school's performance and the students' performance, would be judged by students' scores in the final examinations, which are conducted in the English language.

The difficulty here goes to whether the students would be able to have a good mastery of both the English language and the mathematics concept they needed to pass the examination by the time they get to their final year. The tendency may be that in an attempt to get the students to develop their English language skills and school mathematics competencies, the students may end up not attaining enough of both by the time they sit for their final examination in grade nine.

Teachers' language preference by topics showed that the majority (4 out of 6) of the teachers' language preference by topics reflected their language preference for mathematics generally (see Sections 6.1.3.2 and 6.3.3.2 for example). However, the minority (2 out of 6; TL4 and TW4) of the teachers' language preference by topics varied from one topic to another (see Sections 6.2.3.2 and 6.4.3.2). TL4 for instance preferred to teach fractions in Fante for a better understanding and measurement in the English language because it is not difficult (see Section 6.2.3.2). It is also evident from teachers' results that, like some of the students, some teachers' (TL4's) language preference by topics appears to depend on their perceived difficulty of topics.

Like the students, the preference of the language of instruction in mathematics for the majority of teachers (4 out of 6) generally reflected the language of schooling in Ghana (the English language). Only teachers from School L differed from the language of schooling. The analysis of the data also shows that the language preference of half of the teachers (TC, TW4, TX) from schools C, W, X in mathematics generally, and fractions and measurement specifically, reflected the language they use in school (see Sections 6.1.3.2, 6.4.3.2 & 6.3.3.2 respectively). In School W, TW6's language preference for measurement reflected his language use, but his language preference for mathematics generally, and fractions specifically (English language), differed from his language use (both English and Fante).

In School L (below average achieving school) teachers' language preference differed from their language use. Whilst both sets of teachers said they use English language in teaching mathematics generally, and fractions and measurement specifically (a claim the students results also confirmed, see Section 7.1.2.1 above), TL6 rather preferred to teach mathematics generally in both the English language and Fante, whilst TW4 preferred to teach mathematics generally in Fante to enhance students' understanding. It is evident from this finding that some teachers just follow the language of instruction policy against their wishes. This finding in School L adds to the literature on the influences of political and pedagogical tensions on choice of language of instruction by teachers in bi/multilingual classrooms (Adler, 2001; Setati, 2005a).

Half (2 out of 4) of the headteachers preferred the use of the English language as the medium of instruction (HL and HX), because it is the medium of instruction (HL) or because examinations are in English (HX). The remaining half of the headteachers (HC and HW) preferred a mix of Fante and English as a medium of instruction for mathematics, "for proper understanding" (HW). HC for instance preferred teachers to use the local language as an additional resource for mathematics teaching. Headteachers' language preference differed from the teachers in all the schools. The most notable amongst the schools was School L (below average achieving school) where all the two teachers' language preference differed from the headteacher's;

however these teachers indicated that they use the English language (which is the headteacher's preferred language of instruction) to teach mathematics. It is therefore evident from this finding that, even though some of these teachers are aware that the language they use in teaching mathematics (English) is not in the best interest of the students, they still follow the wishes of their headteacher (which reflects the policy of the day).

In School W, whilst the headteacher (HW) preferred a mix of English and Fante for "better understanding of the lesson," the teachers preferred the use of English. The differences in the headteacher's and teachers' language preference in this school could be explained by the differences in what is important for each of them in mathematics learning. Whilst HW emphasises students' understanding in mathematics learning, TW4 and TW6 emphasise the need to follow the language policy and also the language of examinations (Section 6.4.3.2). Thus, whilst the headteacher appeared to be concerned about students' understanding, the teachers appeared to be concerned about following the policy of the day and students' examination scores. In the researcher's opinion these teachers appeared not to have taken cognisance of the fact that students' understanding of the mathematics concepts also contributes to improving their examination scores.

7.1.3 Effect of the Exposure to School Mathematical Culture on the use of Out-Of-School mathematical Practices in the Classroom Context

It was evident from students' activities that exposure to school mathematical culture generally influenced students' use of out-of-school mathematical practices in the classroom. Neither the grade six nor the grade four students from the four focus schools were able to identify a half in the in-school Task I (a fraction the majority of them indentified correctly in the out-of- school Task II). It is wrong for a person to express a half as "two and a half out of five" (see for example Sections 6.1.1.5, 6.2.1.5 and 6.4.1.5) in everyday situations in Ghanaian culture. It is also unusual for a person to express a half as "two-fourths", as in the case of SX42 for instance (see

Section 6.3.1.1). Thus “nkyekyemu anan mu ebien (two-fourths)” for instance automatically translates to “fã” (a half) in the everyday situation in Ghanaian society. In the same way “nkyekyemu enum mu ebien na fã” (two and half out of five) automatically translates to “fã” (a half) in out of school settings. Thus the notion of “fã” should have rather helped students to get the correct answer to the identification of a half in-school Task 1a, (ii).

However, students’ exposure to fractions in school appeared to exclude this concept of “fã” from the out-of-school mathematical practices. The students’ notion of arithmetic fractions in school was limited to the number of shaded portions in a whole divided by the number of partitions in whole (see for example Sections 6.1.1.5, 6.2.1.5 and 6.4.1.5). SX42’s explanation of two-fourths in the out-of-school task in school as “divide a diagram into four and shade two portions” (see Section6.3.1.5) when describing a fraction of water in a glass sums up how exposure to school mathematical culture affects the use of out-of-school mathematical practices in the classroom context. This finding confirms Walkerdine’s (1988) observation of ways in which schooling could repress mathematical meanings acquired outside schools.

However, both grade four and six students applied their out-of-school mathematical practices in school problems on measurement and problem solving involving multiplication and division of mixed numbers by whole numbers generally. With the exception of grade four students from schools L and X, who requested for measuring scale, none of the students requested for a measuring scale in the measuring activities (see Sections 6.2.1.1 and 6.3.1.2). Both sets of students used the local unit of measure in the activities. This could be cultural and at the same time pedagogical.

As Abreu (1993) observed with children of Brazilian sugar cane farm workers, where children were taught metric systems of measurement in schools while at home they used their local unit of measurement based on ‘braças’, culturally Ghanaians generally use the local unit of measure based on “margarine cup,” “rubber” and

“Olonka” in the out of school setting (see Section 2.3). With respect to pedagogy it appears teachers do not use the measuring scale in class at all. More than half of the teachers (TX, TC, TL6 and TW6) told the researcher through casual conservation after interviews with students that their schools have no measuring scale, so they do not bring them to class when they are teaching measurement.

In dividing ten and half cups of maize amongst three people, however, whilst all grade six students shared the maize equally, irrespective of the ages of those who were sharing (see Sections 6.1.1.2, Figure 6.1.4 for example), grade four students from half of the schools (schools C and X) shared according to ages (see Sections 6.1.1.2, Figure 6.1.4, and Section 6.3.1.2 respectively). This practice of sharing according to ages is associated with out-of-school mathematical practices in Ghanaian culture, where the eldest always takes the bigger share. This is because, if any problem arises from what was shared it is the eldest amongst them who would take the biggest responsibility, the eldest always commands respect. There is therefore this saying in the Fante language that “se erikye adzi a opanyin wo mu [when you are sharing remember the older person]”.

Both the grade six and four students generally approached problem solving involving multiplication of mixed numbers as repeated addition, and division of mixed numbers as repeated subtraction in word problem solving (see Sections 6.1.1.2 and 6.1.1.3 for example). However, whilst all grade four students presented their written solution for word problems involving 6.5 times three as repeated addition after oral computation, grade six students from School W presented their solution as a multiplication sentence, after oral computation involving repeated addition (see Section 6.4.1.3, Figure 6.4.7).

From the results of this study, not many differences were however observed in the way school mathematical culture appeared to influence students’ use of OOSM, perhaps due to the closeness of the grade levels that were chosen for the study. However, grade six students generally appeared to be a little more proficient in the selective use of OOSM in ISM than the grade four students, as none of the grade six students shared according to ages, even though they used the local unit of measure based on empty tins. Also, after using repeated addition to orally work out multiplication problems, some of the grade six students (see Figure 6.4.7, p.270 for example) finally presented their solution as a multiplication sentence, something none of the grade fours did. This finding appears to support Saxe's (1985) study, which also revealed that older students are able to use OOSM to support ISM better than younger students.

In the next section discussions of the results of students' transitions between contexts of mathematical practices will be provided.

7.2 Children's Transition Experience between the School and Home Contexts

It is not clear why Ghanaian students are able to perform mathematical tasks in one context (out-of-school) but find difficulty performing similar tasks in another context (in-school). Abreu, Bishop and Presmeg (2002) have therefore highlighted the need to investigate students' transitions between different contexts of mathematical practices (see Section 2.3). In this section, discussion of students' transition experiences between two contexts of mathematical practices (home and school) and their effects on the students' learning in school will be presented. The section will specifically look at cultural differences that students bring forward in mathematics lessons, ways students make use of their out-of-school mathematical practices in the classroom context, and teachers' and parents' influences on students' mathematics transitions. Relationships between students' language preferences and their thinking language will also be discussed. This will help to unpack some of the struggles Ghanaian primary school students go through as they move between the two cultures of mathematics (ISM and OOSM) and how this may be affecting their learning outcomes in mathematics in school.

7.2.1. Cultural Differences Ghanaian Students bring up in Mathematics lessons

In this section cultural differences that the student participants brought forward through students' activities will be discussed, focusing on differences that were common to all the activities and those that were peculiar to particular activities. Teachers' and headteachers' observations of cultural differences that students usually bring forward in classes in measurement and fractions will also be discussed alongside those that were observed from students' activities and documents to enable the researcher to triangulate what was observed through students' activities and documents with what the headteachers and the teachers said. Cultural difference the students brought forward that was common to all the four activities will be discussed in the next section.

7.2.1.1 Verbalisation and justification of answers through oral computation.

One cultural difference that was brought forward that was common through all the four main activities was verbalisation and justification of answers through oral computation. Students (both grade four and six) from all the four focus schools verbalised their answers to problems. This was then followed by oral explanation of results before written presentation of results (mostly upon the request of the researcher). In solving the word problem involving 6.5 times three, for instance, in School W, SW43 verbalised the answer as "nineteen and half"; SW41 provided oral justification of the answer as:

> we put that of two people together and we had twelve and added that of the third person and we had eighteen and added one half to another half to get one and we added one to eighteen to get nineteen and we added half to get nineteen and a half (see Section 6.4.1.3).

Results from interviews with teachers showed TL6 as also identifying oral computation as a cultural difference which students usually bring forward in mathematics lessons:

> "...classroom work it is always written lesson so children would have to solve things mathematically not saying it orally; they are supposed to work and work and by so doing know how the calculation of certain problems is done but not saying it orally; so that is different from the home." (TL6)

This approach to problem solving may be linked to Ghanaian culture. The culture of writing in the Ghanaian setting is quite recent, as late as the 19th century (see Davis & Ampiah, 2005; Warren, 1976). The Ghanaian culture has been an oral one; that is why Ghanaians have oral literature and oral history for example. Until recently, folklore and puzzles which formed part of the Ghanaian traditional way of building children's critical thinking skills were all presented orally through stories (popularly known as "Anansesem") (see also Zaslavsky, 1973). This oral tradition, which is reflected in oral computation in out-of-school mathematics in Ghanaian society (as already noted in Chapter One), appears to be influencing students' mathematical practices in school. This may also explain why students had difficulty writing mathematical equations to support their answers generally (see Section 6.3.1.4 and 6.2.1.3 for example). In School L for instance, grade six students presented their solution to a word problem involving six and half times three (Task III) as "they get [sic] $19\frac{1}{2}$ " without any mathematical sentence (see Section 6.2.1.3).

However, students' inability to write mathematical equations/sentences could also be pedagogical. One is not sure whether teachers take students through mathematical sentences and how to write those sentences in equation form.

Cultural differences that students brought forward that were peculiar to each of the four main activities will be discussed next in the order of the activities (see Sections 6.1.1, 6.2.1, 6.3.1 & 6.4.1).

The results across the four focus schools showed that of all the four main activities, the identification of fractions in real life situations and the use of measuring scale in measuring were the most difficult for the students (see Sections 6.2.1.1 and 6.2.1.2 for example). Most of the students’ difficulties appear to have their root in Ghanaian culture. This was evident through some of the cultural differences students brought forward in each of the four main activities. Students brought forward five cultural differences in the first activity (identifying, and comparing fractions). These were the use of the same fraction name for different fractions, expressing different unit fractions as a half, a half and a quarter as fraction name often used, exchanging numerator, of a fraction for the denominator and unequal divisions as in the representation of fractions. These will be discussed in Sections 7.2.1.2 to 7.2.1.6.

7.2.1.2. Same fraction name for different fractions.

Students across all the four focus schools used the same fraction name to express different fractions, but when they were requested to identify which of them was bigger they never said they were the same. They indicated that one was bigger than the other. In School W for instance SW61 and SW64 identified one-sixth, one-fifth and three-fifths all as a quarter, but argued that one quarter (one-fifth) was bigger than the other (one-sixth), (see Section 6.4.1.1). The same could be said of school C where SC62 identified one-sixth, a half and three-fifths all as a half (see Section 6.1.1.1), indicating that some halves are bigger than others. This use of same fraction names for different fractions is cultural.

Generally fraction of the form a/b (i.e. fraction as a number) does not seem to have support in Ghanaian culture, although fraction as a proportion does. In Ghanaian society, unit fractions are not usually differentiated when estimating fractions in everyday situations (as already noted in Section 2.3). Thus it is culturally alright to use the same fraction name to express different fractions. This might have accounted for the reason why SW61 and SW64 for example, identified one quarter as being bigger than the other quarter, whilst the two quarters represented different parts of a whole in similar containers. The same reason could be used to explain why grade four students from School L and School X also used the same fraction name to identify different fractions in the in-school task (see Figure 6.2.9 and Figure 6.3.7).

7.2.1.3 Expressing different unit fractions as a half.

Almost all the students from the four focus schools were able to identify a half in the everyday situations (a fraction they could not identify the in-school activities). This could also be explained as cultural. A half is the only fraction that has a specific name in Ghanaian culture ("fã"), so it was easy for students to identify a half in the task. However, "fã" (as in a half) does not always mean the exact midpoint (as already noted in Section 2.1.3). It could be above the midpoint or in some cases even below the midpoint. Thus a half could be interpreted as "fã" or "sin"(less than a whole).

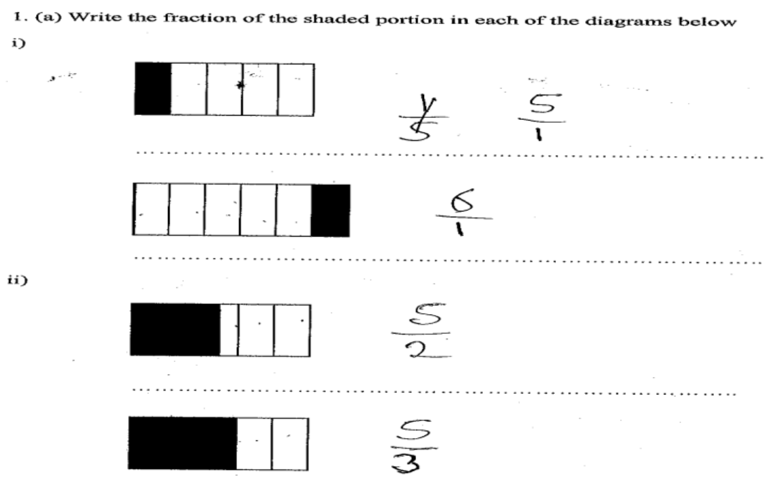
This different identification of a half was exhibited by SC62, for example. In Task 1, SC62's use of a half for one-sixth connoted a half as in "sin", whilst SC62's use of a half for the exact midpoint (a half) and about the midpoint (three-fifths) connoted a half as "fã". It is evident from the result that different meaning of "fã", which literally means a half in English, appears to create cognitive conflict for students in the identification of fractions in the real life situation.

7.2.1.4 A half and a quarter as fraction names often used.

Throughout the activities in the four focus schools, the most common fraction names that were often used in the majority (3 out of 4) of the schools were a half and a quarter. This could also be more cultural than cognitive. Ghanaian society appears to be still quite undeveloped despite attempts towards modernisation (see GNA, May 2009a; GNA, May 2009b). Measurement in Ghanaian society is still quite primitive (as already noted in Section 2.3). Measurement of liquids such as liquor and kerosene for instance involves three main units of measure. These are “one bottle”, “half” and “quarter”. The responses of grade six students from School L in the activities on the identification, and comparing of fractions (“one whole”, “half” and “quarter”) (see Table 6.5 and Table 6.6) appeared to reflect all the three units of measuring some of these liquids. Thus the fact that the researcher kept pouring water from a bottle into the glass which was visible to the students might have suggested to some of the students who wanted to guess that it could either be “a half” or “a quarter”.

7.2.1.5 Exchanging numerator of a fraction for the denominator.

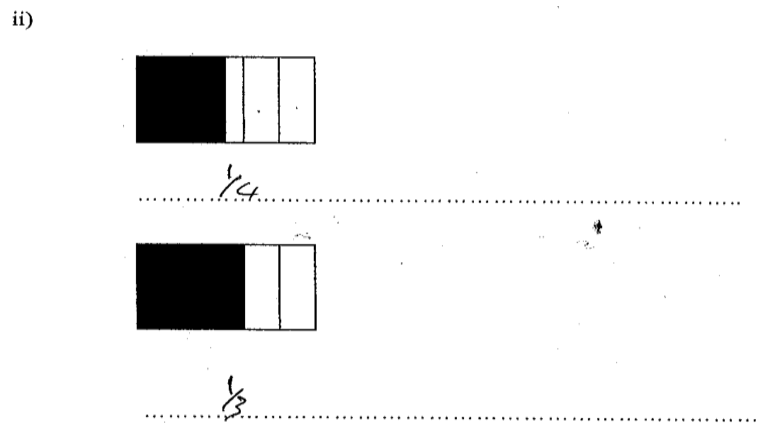
Even though SL42’s representation of common fractions, exchanging numerators for the denominators as shown in Figure 6.2.2, could be cognitive; it also appears to suggest a possible cognitive conflict that may be emanating from the local names of each of the fractions. One-fifth in the Fante language is “nkyekyemu enum mu kor”, “enum” means five (which SL42 wrote as the numerator instead of the denominator) whilst “kor” means one (which SL42 wrote as the denominator instead of numerator). In the same way one-sixth is “nkyekyemu esia mu kor”, two-fifths is “nkyekyemu enum mu ebien” and three-fifths is “nkyekyemu enum mu ebasa” (see Warren, 1976).



Thus in the local language (Fante) the denominator is mentioned before the numerator. An attempt to literally translate fraction names from the Fante language to the English language would result in the way SL42 represented the fractions. This might explain why SL42 was consistently representing fractions exchanging numerators for denominators as shown in Figure 6.2.2. This finding confirms links between language and cognition (Shǜtz; 2004; Sutherland, 1992). Thus SL42's knowledge of the Fante name for common fractions appeared to create cognitive conflict in the representation of fractions in school.

7.2.1.6 Unequal partitioning of whole.

The next and the final cultural difference which students from all the four focus schools brought forward in activities involving identification and comparing of fractions was unequal division in sharing as in fractions. Students across the four focus schools partitioned wholes into unequal parts. Some of the evidence from students' worksheets also suggested that they did not think about sharing, as in division, as involving equal division, confirming the observation the researcher earlier made from lesson observation on fractions in Chapter one (Section 1.4). A typical example was in School X, where grade four students identified the fractions below as a quarter and one-third respectively (see Section 6.3.1.1).



It could be observed that what students identified as a quarter is actually a half and what they identified as one-third is actually three-fifths. Thus students' notion about sharing in the out-of-school context, which does not necessarily mean equal sharing (as already explained in Section 2.1.3), appears to create cognitive conflicts in school mathematics, even when they have to share things equally.

Cultural differences that students brought introduced in division of fraction/measuring through students' activities will be discussed next. Students introduced what appeared to be three main cultural differences through activities on division of fraction/measuring. These were the use of local units of measure (as already noted in 7.1.3), division as repeated subtraction, and issues about fair share. These will be discussed in Sections 7.2.1.7 to 7.2.1.9.

7.2.1.7 Use of local units of measure.

As already noted in Sections 7.1.3 above, the majority of the students used the empty margarine tins in the activity. Even in school L where grade four students used the measuring scale on three occasions (see Sections 6.2.1.2 and 6.2.1.6), they finally requested the local units of measure because; "when we use it we shall see the answer easily" (SL43) (see Section 6.2.1.6). This finding is similar to those of Owens and Kaleva (2007) whose study with teacher education students in Papua New Guinea also found an extensive use of informal units of measure. Interviews with teachers revealed some as confirming local units of measure as cultural difference which students bring up in mathematics lessons; "when teaching of measurement they are able to mention the local units like the milk tins and the Milo tins and others..." (TC).

This use of the local units of measure is mainly cultural, because the SI units of measuring capacity based on grams and kilograms, and distances based on meters, kilometers, miles remains an abstract school concepts. See below for example of the units of measures used in an excerpt from an address by Mr. Akuffo Addo, a Ghanaian opposition leader, on the state of the Ghanaian economy, highlighting the increasing cost of living in Ghana (GNA, May 2009b):

THE RISING COST OF LIVING

Here are some examples of what I am saying:

ITEM	PRICE IN JANUARY	PRICE IN MAY	UNIT OF MEASURE
Gari	GH¢1	GH¢ 1.60	**Olonka**
Maize	GH¢1.70	GH¢2.50	**Olonka**
Yam	GH¢1.50	GH¢3.00	**Tuber**
Rice	GH¢63.00	GH¢75.00	**50-kilo bag**
Plantain	45 pesewas	GH¢1.00	**5 fingers**
Vegetable oil	GH¢2.50	GH¢3.50	1 liter
Tomatoes	50 pesewas	GH¢1.00	**Four small fruits**

A look at the units of measures used for tomatoes, maize and plantain for example, from the excerpt of the address, supports the researcher's argument that the SI units of measure remain mainly an abstract school concept in Ghanaian society.

Also unknown distances are usually described in terms of known distance. For instance the distance from Town A to Town C may be described in the out of school situation, in most cases, in relation to a known distance from say Town X and Town Y. Thus the distance from Town A to Town B may be described as being "half of" or "same as" or "twice as" the distance from Town X to Town Y. This cognitive conflict appears to influence students' conceptions and practices in measurement in school (as was exhibited by the grade four students from School L for example).

The next cultural conflict that will be discussed is division as a repeated subtraction, which Nunes, Schliemann and Carraher (1993), also identified as an out of school mathematical practice.

7.2.1.8 Division as repeated subtraction.

Students from each of the four focus schools approached division as repeated subtraction. Even students who used scale also approached division as repeated subtraction; “let us give each of them thousand five hundred” SL44 (see Section 6.2.1.6). This suggests that students repeatedly subtracted 1500 from 4500; an approach which is linked to out-of-school mathematical practices. It is also evident from the difficulty these grade four students had in finding the appropriate operation sign to justify their correct answer that they appeared to be very proficient in division using out-of-school strategies but not in-school strategies (see Figure 6.2.4 for example)

1500 g

$$\begin{array}{r} 4500\text{ g} \\ \div\ \cancel{\times}\quad 3 \\ \hline 1500\text{ g} \\ \hline \end{array}$$

Differences underlying the assumptions in division in school and out of school in Ghanaian society might account for the use of division as a repeated subtraction. Unlike school, where homogeneity is assumed and therefore items are automatically divided equally, in the out of school situation the assumption of homogeneity does not always hold, except in the case of sharing money.

In sharing rice for instance, it is unlikely for those sharing to assume that the whole bag of rice is wholesome. In reality quite a number of the students sell rice (see Section 6.2.6 for example) so they are aware that many of the rice grains get rotten towards the bottom of the bag of rice. Based on this knowledge it would not appeal to students to share a given quantity of rice by dividing it by the number of people sharing, because some would get more unwholesome rice than others. In order to ensure fair share, they would rather approach the division as a repeated subtraction.

This out of school notion also appears to be creating conflict in the minds of students, as was seen throughout the four focus schools. It also has implication for mathematics pedagogy, especially in problem posing in class. Related to this issue of fair share is that of sharing according to age, which will be discussed in the next section as the next cultural difference students brought up through the activities on division of fractions/measuring capacity.

7.2.1.9 The notion of fair share.

Issues about fair share in the out of school context and school context appeared to create cognitive conflicts in the minds of some of the students. In School C, for instance, the conditions for sharing amongst grade four students changed as they got to know more about those who were sharing (see Sections 6.1.1.2 and 6.1.1.6) (Note that the question did not request the focus group participants to share the items amongst themselves). In Section 6.1.1.2, when the grade four students did not have information about their ages, in sharing ten and half cups of maize, SC41 (eldest by appearance) had four cups, SC43 (next eldest by appearance) took three and half cups, and SC44 (youngest by appearance) took three:

> because all of them cannot get four; SC41 is older than the two of them so she takes four and SC44 is older than SC43 so he takes three and the remaining. SC43 takes three because she is the youngest among them. (SC42)

However, in Section 6.1.1.6, when students became aware that SC44 and SC43 were of the same age, the conditions for sharing changed. This time both SC44 and SC43 took the same quantity:

> it is the remainder; it is too small for me to share it among them. I cannot give it to either of them [referring to SC44 and SC43] because they are of the same age and if I give it to SC41 that would be too much, so I will keep it. (SC42)

Interviews with teachers revealed the majority (4 out 6; TC, TW6, TW4 & TX) of them as also confirming unequal sharing in fraction as in division as a cultural difference students bring up in lessons on fraction. In School C, TC, whose students shared according to ages, said "... when it comes to sharing between an elderly person and then a younger person the application [of fractions] doesn't hold"; TW4 also explained the situation in her class as follows:

> let's take that the thing is one whole like a loaf of bread call three pupils to come and share it under the topic of the thirds. You will find out that they would not be able to share it equally; one person may think I am the eldest and others may think I am also grown so they would not be able to share it equally...

It is evident from the results that some of the students' notion of fair share was not equal sharing (as in the school situation). Their notion of fair share was based on the out of school notion of fair share (that is, what is acceptable to those sharing) as already noted in Section 2.1.3. This notion of fair share also has implication for posing problems solving questions on division involving human beings for example, or anything that may be conceptualised as one being senior to the other. Even though this out of school notion of fair share may support the concept of proportion in future; it is evident from the results of this study that it appears to create cognitive conflict for students. Cultural differences that students brought up through activities on the multiplication of fractions/measurement of capacity will be discussed next.

Students across the four focus schools introduced two main cultural differences through the activities on the multiplication of fractions/measurement. These were multiplication as repeated addition and the use of finger counting. The details of these will be discussed in Sections 7.2.1.10 and 7.2.1.11.

7.2.1.10 Multiplication as repeated addition.

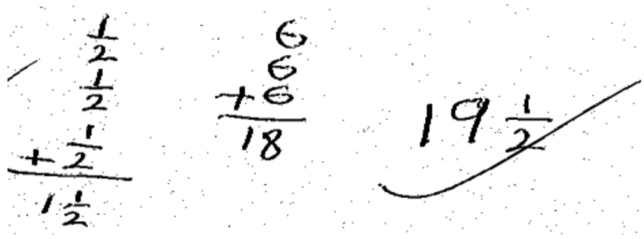
With the exception of grade six students from School W who approached the task from the perspective of multiplication as a product (see Sections 6.4.1.3 and 6.4.1.7), all students approached multiplication as repeated addition (see Sections 6.1.1.3, 6.1.1.7, 6.2.1.3, 6.2.1.7, 6.4.1.3 and 6.4.1.7). In solving the word problem which required student participants to find the quantity of rice Esi bought if Ama bought 5.5kg and Esi bought thrice the quantity of rice Ama bought (see Appendix H02, 2(b)), the grade six students in School W, presented their solution as a multiplication sentence, as shown below (see Section 6.4.1.3; Figure 6.4.7).

$$\begin{array}{r} 5.5\,\text{kg} \\ \times\quad 3 \\ \hline 16.5\,\text{kg} \end{array}$$

In School C for example, grade six students presented their solution to the same problem as a repeated addition, as shown below (see Section 6.1.1.7; Figure 6.1.14);

$$5.5\text{kg} + 5.5\text{kg} + 5.5\text{kg} = 16.5\text{kg}$$

The majority (7 out of 8) of the focus group students' approach to multiplication as a repeated addition appears to be cultural as well. In the out of school setting "mboho" is used to denote multiplication but it is easier to talk about "mboho" as a repeated addition than a product (as it is in multiplication in school). Thus "esia mboho anan [four groups of six]" is usually approached as six plus six plus six plus six but not six times four or four times six as in school. This confirms the literature that has suggested that this approach to multiplication is usually associated with the out of school practices (Nunes, Schliemann & Carraher, 1993). Related to multiplication as repeated addition is the use of the decomposition method in adding mixed numbers, which most students, especially grade four students, employed in simplifying the sum of given mixed numbers (see Section 6.1.1.7, Section 6.3.1.7, Figures 6.3.8). In School X for instance SX62 presented the group's solution to 6.5 times three as shown below (see Figure 6.3.8):



The decomposition method of solving mathematical problem is also practiced in the Ghanaian culture. Other researchers have also linked this practice to out of school mathematical practices (Nunes, Schliemann & Carraher, 1993). In Ghanaian culture this practice usually goes with oral computation (which has already been discussed above).

7.2.1.11 Finger counting.

Students across three out of the four schools accompanied their oral computation with finger counting in finding solutions to word problems involving multiplication of mixed numbers. In School L for instance, SL63 counted the fingers in an attempt to solve an out-of-school task involving six and half times three, whilst SX64 and SW43 used similar approaches of finger counting in schools W and X respectively (see Sections 6.2.1.3, 6.3.1.3 and 6.4.1.3 respectively).

Interviews with the teachers and headteachers also showed some of them as saying students used finger counting in class; “whenever we engage in counting you may see some of them counting their fingers and toes, ... when measuring some also use their span in measuring,” (TX) “well sometimes when the teachers are teaching children tend to bring the ideas they have in the home; for example counting of fingers they do it in the house so they tend to bring them.”(HL) Cultural differences that students’ brought up through activities on the addition of fractions/measurement of area will be discussed in the next section.

Students brought up one main cultural difference through activities on the addition of fractions/measurement of area. This was rounding of measurement.

7.2.1.12 Rounding of measurement.

The results across the four focus schools revealed that grade four students in School C and grade six students in School X, for example, ignored the fractional parts of the whole in measuring the area of the citrus farm in the out-of-school task; "there are four 'poles' in the area of the citrus farm," (School C students) "let us take it to be four" (SX64) (see Sections 6.1.1.4 and 6.3.1.8). Thus they rounded their answer to four.

During the interviews with teachers, TW6 confirmed that students use rounding of figures in measurement in class; "I give them measurement of paper strip they tend to add their own thing to round it up; like what is being done outside the school." (TW6)

This practice of rounding measurement to a whole is usually associated with the out-of-school mathematics in Ghanaian society. Out-of-school mathematical practices in Ghanaian society deal more with discrete numbers rather than with continuous numbers. This was evident in SC42 and SX44's reasons for not sharing a half, but rather keeping it as a remainder; "it is a remainder; it is too small to share amongst them [referring to SC44 and SC43]…" (SC42), "it is not sufficient." (SX44)

In Section 7.2.1 twelve cultural differences were identified and discussed. This shows that even though all students identified OOSM as being different from ISM, and ISM as more important than OOSM (in Section 7.1.1.1), that did not stop them from bringing up cultural differences. This confirms the literature that learners bring their everyday knowledge to learning situations, they do not leave them at the gate of the school (Bishop, 2002; Fleer & Robbins, 2005). It was however evident from the discussion that not all the cultural differences were confirmed through interviews with teachers. This could be due to the fact that questions that were posed to teachers were mainly on measurement and fractions generally, but not on specific concepts such as identification of fractions and operations on fractions or operations on measurement. Whilst culture difference such as multiplication as repeated addition and decomposition method of addition confirmed what already existed in the literature (Nunes, Schliemann & Carraher, 1993), the cultural differences in fractions adds a new dimension that could influence students' learning outcomes in fractions (Sections 7.2.1.2 to 7.2.1.6 and Sections 7.2.1.8 and 7.2.1.9).

In the next section ways students made use of OOSM in ISM in the classroom context from the results presented in Chapter Six will be discussed.

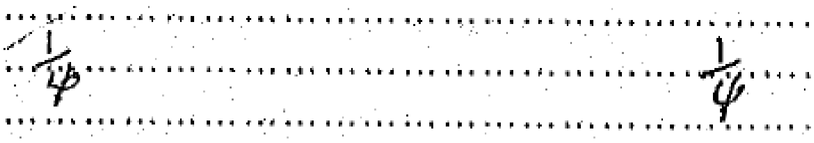
7.2.2 Ways Children make use of their Knowledge of Out-Of-School Mathematical Practices in the Classroom Context

The results from students' activities across the four focus schools show that students made use of some OOSM in ISM, irrespective of the school type, in all the in-school activities, despite their perceptions of OOSM and ISM as being different. In fractions partition of wholes were done unequally in the in-school activities (see Section 6.1.1.5; Figure 6.1.3 for example), in division as fractions in school, sharing were done according to ages in some cases (see Section 6.1.1.6 for example), and in measuring students across all the school types made use of margarine cups. The decomposition method was employed in addition of fractions, while division of fractions was approached as repeated subtraction. Multiplication of fractions was also approached as repeated addition in most cases (as already noted in Section 7.2.1).

However the results showed that practical activities evoked out-of-school mathematical thinking and strategies whilst paper pencil activities also evoked in school mathematical thinking and strategies in some cases. This was evident in the identification of fractions, and finding the area of a rectangle (sees Sections 6.1.1.1 and 6.1.1.5; Sections 6.1.1.4 and 6.1.1.8 for example). In identifying fractions in the real life situation, students across all the four school types often used the same fraction name to describe different fractions, a practice which is linked to out-of-school mathematical practices in Ghanaian culture (see Section 7.2.1 above). In

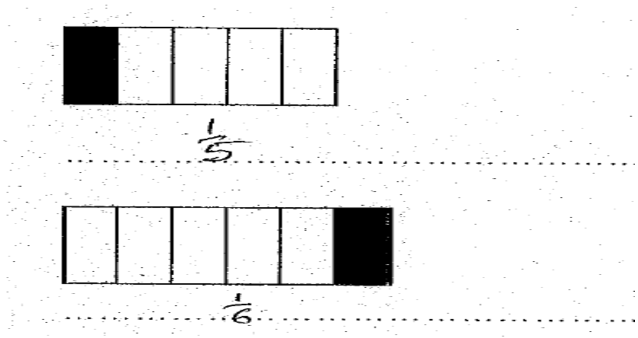
School W for instance, grade six students identified a glass one-sixth full of water (Glass A1) as a quarter and a glass one-fifth full of water (Glass B1) also as a quarter:

Glass A1 Glass B1



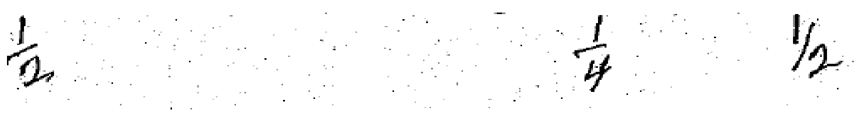
but argued that one-quarter (Glass B1) was more than the other quarter (Glass A1).

However, in the paper and pencil task the same group of students identified one-fifth differently from one-six

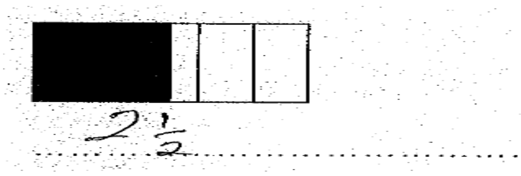


Also whilst all students in the same school were able to identify a glass half full of water (Glass A2) in the real life situation as half:

Glass A2 Glass B2

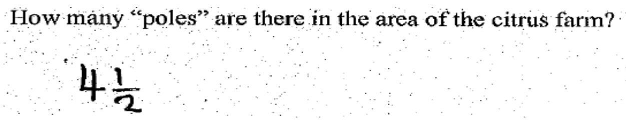


None of them was able to identify a half in the paper pencil task;



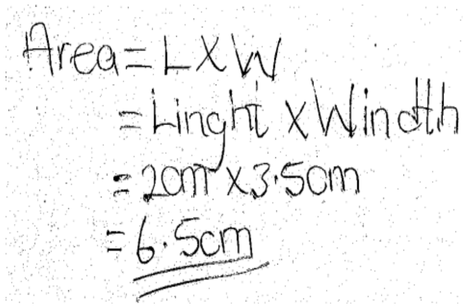
Students' approach to identification of one quarter as being more than the other quarter whilst these quarters reflected different parts of a whole in the real life situation, is a reminiscence of a similar logic in the out-of-school mathematical practices in fractions, where the same fraction name used to describe different parts of a whole. Also “fã” as in a half in the out-of-school practices means about the midpoint (as already noted), hence in the real life situation they could all think of the midpoint as a half. However in the paper and pencil task they did not think about midpoint (a half) as in “fã”. Thus their notion of part-whole relationship in school evoked the school approach, which appeared to limit their notion of part-whole relationship to number of shaded portions divided by the total number of partitions in the whole.

In finding the area of a rectangle in school, even though grade six students from school C and X verbalised their answers before solving the problems, it was evident that the practical activities evoked out-of-school mathematical thinking, whilst paper pencil activities evoked in-school approaches. In School C (see Section 6.1.1.4) for instance grade six students approached the measurement of area of $2\frac{1}{4}$ “pole” by 2 “pole” area by measuring with the unit square and just writing their answer as;


How many “poles” are there in the area of the citrus farm?

$4\frac{1}{2}$

Grade six students from School C provided no written explanation of their approach such as “$4 + \frac{1}{4} + \frac{1}{4} = 4\frac{1}{2}$,” neither did they provide a diagrammatic explanation of their answer in the focus group interviews. This practice of not showing a written explanation is very much associated with out-of-school mathematical practices, where oral explanation is often used instead of written explanation. In school, however, students used mathematical sentences (formula) to explain their approach to finding the area of the rectangle:


Area = L X W
= Linght X Windth
= 2cm X 3·5cm
= 6·5cm

Interviews with teachers and headteachers across the schools revealed all of them as also confirming some use of OOSM in the classroom. In School C for instance TC said she uses OOSM in ISM by way of role playing; “by role play; for example if I am teaching word problems involving addition or subtraction then they role-play where one acts as a father or a mother asking the son to buy certain things and give a certain amount...” The Headteacher of School W (HW) also confirmed the use of OOSM in ISM usually through role-play; “they use the role-play in their teaching like buying and selling...” (HW) (see Section 6.4.4.2). Other teachers said they made use of OOSM in ISM during the introduction of the lesson. In School X for instance, TX explained:

> ... before I start my lesson I draw on pupils’ knowledge on sharing that they engage in at home by giving them things to share. The way they share at home will be exhibited in class because this is how they have been introduced to may be by their parents or ..., so it is the school that when they come changes may occur.

Some of the headteachers also confirmed the use of OOSM, usually in the introduction of lesson:

> the kids, most of them sell after school so they know this kind of measurement, the addition they know, subtraction and what have you… it is like when they come it is used as their RPK [Relevant Previous Knowledge], which enhances introduction of the lesson and it makes the lesson very lively and understanding. (HC)

However, responses of some of the headteachers and the teachers show that the use of OOSM in class is restricted to those that support ISM. TW4 for instance explained; “sometimes they [students] get motivated, they already know how to share, they are eager to learn but they would find out that how they share at home is not how they are going to share in school ...”(TW4) Implying that students out-of-school notions of sharing become irrelevant in class. This situation might have contributed to TW4’s thinking about the use of OOSM in ISM when she said that;

“they [students] must always make sure that whatever they learn in class they would apply but rather they shouldn’t apply what they know from the market to the classroom.”(TW4) This observation about the use of OOSM which are perceived to support ISM was also confirmed from documentary evidence from teachers’ marking of students’ activities. An example was in School C where TC rejected the use of out of school logic by students in the sharing of ten and a half cups of rice among three people (see Section 6.1.5; Figure 6.1.17 for example). Responses from some of the headteachers also confirm that teachers usually encourage use of OOSM which support ISM; “they [students] all share, if it is good for them they take it.” (HX)

With the exception of TW6, all teachers perceived the Ghanaian language policy as affecting the use of OSM in ISM. In School L for instance TL4 explained:

> it affects it because the mathematical ideas in teaching in outside the school is in Fante throughout so if you bring it to the classroom sometimes you find it difficult to translate it to English that makes it difficult for the pupils to understand, yeah. (TL4)

TL4’s observation about the difficulty in translating mathematical ideas from Fante to English is an important one. This is because an attempt to translate all mathematical terms from the local language into the English language or vice versa may create more confusion for students. The local language could be used, but the technical terms in mathematics may have to be maintained. This is because the local language is not developed alongside the technical language of mathematics; for instance the term “difference” as used in subtraction may confuse students when it is translated from the local language to the English language. This is because in the Fante language for example, “nsonsonoye” (difference in English) is used to express difference in qualities not quantities. Thus using “nsonsonoye” for quantities as in mathematics in school would rather confuse students, because in the out-of-school situation students do not use “nsonsonoye” (difference in English) to compare numbers. “Nsonsonoye” is used to compare all other things except quantities. Thus it is possible for a child to give an answer to the question “eben nsonsonoye na owo

100 na 10 mu [what is the difference between 100 and 10]" as ten having one zero whilst hundred has two zeros.

As with teacher TW6, the majority (3 out 4) of the headteachers did not believe the language policy of Ghana affects the use of OOSM in ISM. It appears from some of the headteachers' responses such as "because we do not have English name for 'atuwudu', 'Olonka' and so on we can use their [local] names" (HX), that some the headteachers believe teachers can keep technical terms in either the local language or English and still use the language of their choice to teach mathematics. This is an indication of HX's support for code-switching in mathematics lessons (see Baker, 1993). Thus teachers do not need an English term for "Olonka" for example before they use them when they are using the English language as a medium of instruction. In the same way teachers do not need to replace difference (as in subtraction) with a Fante term when they are using Fante as the medium of instruction. It is therefore not surprising that the majority of the headteachers' views differed from those of the teachers.

The researcher will now turn to relationships between the language(s) students said they preferred to study mathematics in and those that they said they used in thinking.

7.2.3 Relationship between Students' Preferences for Language of Instruction and their Thinking Language

Analysis of the data on students' thinking language across the four focus schools showed that the majority (25 out of 32) of them said they thought in Fante (local language) during the activities. A few of them said they either thought in English (SX61, SL63, SL64, SL42 and SL44) or in both English and Fante (SW62 and SW63) (see sections 6.1.1, 6.2.1, 6.3.1 and 6.4.1).

However, findings from students' preference for the language of instruction showed that the majority (27 out of 32) of them said they preferred to learn mathematics in

English (see Section 7.1.2.1). Only one (SC43) said he preferred to study mathematics in Fante, whilst the remaining four of them (SX61, SX62, SX63 and SX64), all grade six students from School X, said they preferred to learn mathematics in both the English language and Fante (the local language).

Analysis of data on students' language preference and their thinking language show evidence of gaps between the majority (24 out of 32) of the students' thinking language and their preferences for the language of instruction. Only 5 out of 32 (SC43, SL63, SL64, SL42 and SL44) had their language preference exactly reflecting their thinking language.

Thus the results showed that student SC43 said he thinks in Fante and preferred to learn mathematics in Fante, students SL63, SL64, SL42 and SL44 said they think in English and preferred to learn mathematics in English. Students SX62, SX63 and SX64 said they think in Fante but they preferred to learn mathematics in both Fante and English language, whilst student SX61 said she thinks in the English language but preferred to learn mathematics in both English and Fante. The remaining (24 out of 32) students said they think in Fante but preferred to learn mathematics in the English language.

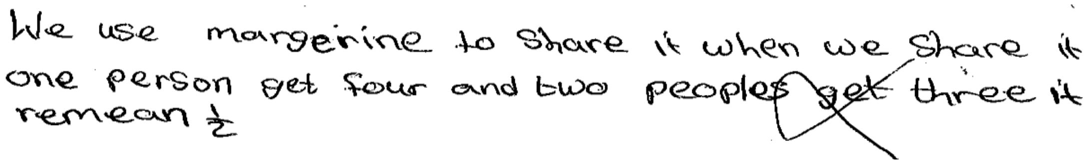
This gap in most of the students' language preferences and thinking language was evident in students' approaches to word problems, as they code switched from the English language to Fante and back to the English language in their attempt to understand, devise solutions to the questions and present their final answers (see Section 6.1.1.7 for example).

In the next two sections how teachers handle cultural differences students bring up in mathematics lessons and why they handle them the way they do will be discussed.

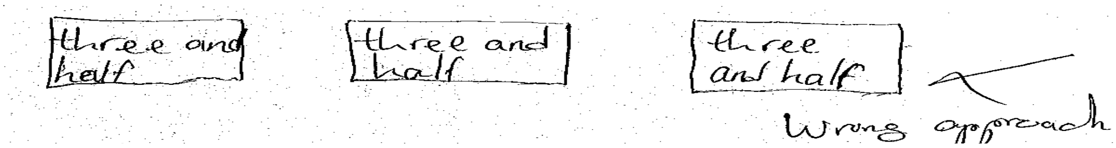
7.2.4 How Teachers Usually Handle Cultural Differences

Analysis of the results from the interviews with teachers across the four focus schools showed that they either reject or discourage students from using some of the out-of-school cultural notions they bring forward in mathematics lessons. This was evident in how some of these teachers said they handled cultural differences students usually bring forward; “I don’t give them the chance to measure the way they do at home…” (TW6); “when I see them using those things [referring to counters] I normally don’t agree; I seize them…” (TW4); “I discourage them…” (TX).

Analysis of documents also confirmed that some teachers reject cultural differences such as non-algorithmic approaches to problem solving. Some examples of evidence of how some teachers rejected cultural differences from document analysis are presented in Figure 7.1 below.


We use margerine to share it when we share it one person get four and two peoples get three it remean ½

(Teacher TC)

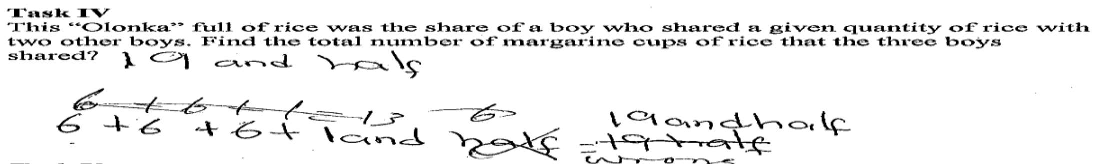

three and half

three and half

three and half

Wrong approach

(Teacher TW6)

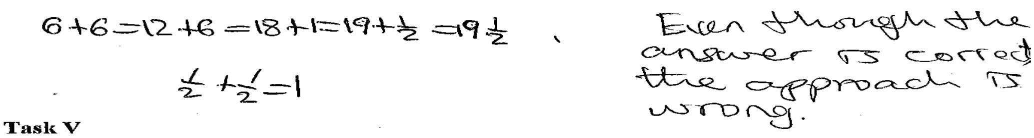

Task IV
This “Olonka” full of rice was the share of a boy who shared a given quantity of rice with two other boys. Find the total number of margarine cups of rice that the three boys shared? 19 and hals

~~6 + 6 + 1 = 13~~ 6

6 + 6 + 6 + 1and ~~half~~ = ~~19 hafe~~ 19andhalf

wrong

(Teacher TX)


6+6=12+6=18+1=19+½=19½

½+½=1

Task V

Even though the answer is correct the approach is wrong.

(Teacher TC)

Figure 7.1. Ghanaian primary school teachers’ handling of some students’ mistakes.

Analysis of documents shows that teachers from all the school types reject some cultural differences students bring forward in mathematics lessons. Results from the analysis of teachers' interviews show that teachers rather concentrated on the school's way of doing mathematics. This was evident in their responses such as; "they [children] know the home one so if they bring it up you teach them what the syllabus says or what has been prepared to be followed" (TC); "I try to tell them to put aside culture from the house and learn the one in the school ..."(TW6).

Interviews with headteachers revealed some of them confirming the observation that teachers concentrate on school mathematics. In School C for instance HC explained how teachers handle culture difference students bring forward in measurement as; "the teachers take them through the units of measurement, that is, units assigned. They normally take them through cm, metres, mm, kg and what have you. They take them through those terms used before they introduce the actual measurement." (HC) This implies students are "inducted" (see Bishop, 1988) into schools' unit of measurement before measuring begins; indicating that the out-of-school unit of measure has little place in this approach. However, this strategy of concentrating on the school's way of doing mathematics does not appear to stop students from bringing up all kinds of cultural differences (as was observed in students' activities). All these may be contributing to students' perceptions of the difference between in-school and out-of-school mathematics. This finding adds to the body of literature showing that teachers make it impossible for students to engage in cultural interaction even when students made the initiative (Bishop, 2002). It also confirms the literature that teachers make no reference to out-of-school mathematics once they are aware that in-school and out-of-school mathematics are mutually exclusive (Abreu, 1995).

In the next sections the reasons teachers gave for the ways they handle cultural differences will be discussed.

7.2.4.1 Reasons teachers handle cultural differences the way they do.

Results from interviews with teachers across the four focus schools show that the reasons why teachers handled cultural differences by mainly concentrating on school ways of doing mathematics were mainly curricula and psychological. Some of the curricula reasons included the need to follow what the mathematics syllabus says; "that is what the syllabus that has been provided for us to follow says" (TC); "…because assessment would be based on what is learnt in the school but not what is in the out-of-school" (TW6). Thus the pressure of following the school syllabus, as Abreu (1993) observed, and the fact that at the end of the day students' assessment would be based on their mastery of ISM but not OOSM, appear to be the main reasons why some of the teachers handled cultural differences by concentrating on the school mathematics.

Some of the psychological reasons some teachers gave included; "I think at that level [grade four] they shouldn't be using those things [counters] in doing mathematics...I want them to use this thing [pointing at the head]" (TL4); "I discourage them but I don't discourage them outright because we have individual differences and the learning abilities of one pupil differ from the other..." (TX). TL4's explanation shows clearly that he rejects the use of counters in grade four because students at that level must have passed the stage where they require concrete props to support their learning. It appears he expects students at that level to abstract mathematical concepts without the use of concrete props. There is evidence of influence of stage theory which emphasises the innate ability of the learner (as already explained in Section 2.1.3). This also confirms the earlier observation of the researcher in Section 2.1.3 that the Piagetian theory seems to influence mathematics curriculum delivery in Ghanaian schools so much that the culture of students and teachers has little or no place in mathematics curriculum delivery.

It is evident from the discussion in Section 7.2 so far that the fact teachers reject or discourage cultural differences because of curricula or psychological reasons does not stop students from employing differences in mathematics lessons. It appears from the findings on ways teachers handle cultural differences that teachers' knowledge about students' culture is a necessary (see Section 2.2.1) but not sufficient condition for the strengthening of cultural support for students' mathematics learning in school. It appears what counts as mathematics to be included in the school curriculum and hence teacher development programmes is equally important.

7.2.5 Teachers' and Parents' Influences on Students' mathematics Transition

The literature highlights the importance of parents' and teachers' communication, and parents' support for students' mathematics learning in students' mathematics transitions (see Abreu & Cline; 2003). In this section the discussion will focus on the general situation of parents' and teachers' influences in students' mathematics transitions across the four focus schools, when does it become necessary for schools to encourage parents' and teachers' collaboration, and what is included in parents' and teachers' collaboration. Discussion will also be provided on why schools do not encourage parents' and teachers' collaboration in students' mathematics transitions.

The results across the four focus schools revealed that half (3 out of 6) of the teachers (TC, TX and TL4) said that they collaborate with parents in students' mathematics transitions. The majority (3 out 4) also said their schools encourage parents' and teachers' collaboration in students' mathematics transitions. With the exception of School L, where HL's response (that the school encourages parents' and teachers' collaboration in students' mathematics transitions) confirmed that of TL4 but contradicted that of TL6 (probably because HL was describing the general situation in her school), headteachers' responses generally confirmed those of their teachers (see Sections 6.1.6; 6.2.6; 6.3.6 and 6.4.6). In schools C and X both the teachers and headteachers said teachers collaborate with parents in students' mathematics transitions. In School W both the teachers and headteachers said there was no collaboration between teachers and parents in helping students' mathematics transitions. Surprisingly School W, which happens to be the only above average achieving school amongst the four focus schools, said they did not encourage parents' and teachers' collaboration in students' mathematics transitions, whilst the only below average achieving school said they rather encouraged parents' and teachers' collaboration in students' mathematics.

Results from both the teachers and the headteachers in schools that said they encouraged parents' and teachers' collaboration in students' mathematics transitions showed that parents' and teachers' collaboration in this transition becomes necessary when students are performing poorly in ISM; "there are some of the children who are very weak in the subject, so if such a pupil is observed then the parents would be invited..." (TC, Section 6.1.6); "well when we feel that for example a child is not all that good in an area we invite the parent..." (HL, Section 6.2.6); "it is when we realise that the concept stated in mathematics syllabus is different from what the children give us ... it is then that we say that we should rely on the parents." (HC)

Parents' and teachers' collaboration also becomes necessary when students have other problems; "sometimes I find that a child is very good but always sleeping in the classroom so I call the parent..." (TL4, Section 6.2.6); "when children misbehave or when we find out that children are playing truant or they are in bad company," (HL; Section 6.2.6) "…some of children absent themselves too much from school" (HX; Section 6.3.6). Thus parents are invited to the school mainly when there is a problem either with studies of their children or when their children have behavioural problems.

The data suggest that parents' and teachers' collaboration in students' mathematics transitions appears to be mainly in the form of an expert-novice relationship, where the "expert" teachers offer pieces of advice or suggestions to the "novice" parents. This was evident in how teachers explained the role of the parents in the collaboration; "by inviting the parents and talking to them about child's performance and then suggesting solutions..." (TC, Section 6.1.6); "I call the parent and they come ... so I tell them it is not good it would affect the child" (TL4; Section 6.2.6); "I edge the parents to sit their kids down and then learn some mathematics since they tend to forget when they don't practice" (TX; Section 6.3.6).

Parents' and teachers' collaboration in students' mathematics transitions was not encouraged in School W because of parents' educational background; "most of the parents are illiterate so they would not get the knowledge to help the children to study mathematics," (TW6) also because of the nature of parents' knowledge; "their knowledge is informal but in the school we deal with the formal knowledge, so the informal and the formal cannot meet, that is why," (TW6) and finally because the teachers have been trained to teach the children and they follow the curriculum; "the whole thing is the teachers have been trained to teach the children and they follow let say a pattern from the curriculum..." (HW) This finding is not surprising to the researcher, since teachers rejected cultural differences in school, it follows that some would reject collaboration with parents once they are aware that parent's knowledge is mainly informal; especially having in mind that they have to follow curriculum which gives very little room for out-of-school mathematics. This finding shows the tendency for schools to look down on parents' knowledge because of parents' educational background.

In this Chapter discussions on sociocultural influences on students' mathematics conceptions and practices as well as their transitions between home and school mathematics were provided. In the next chapter conclusions based on discussion in Chapter Seven will be drawn. Implications from the conclusions will also be discussed.

Chapter Eight - Conclusions and Implications

Students' performance in mathematics in Ghana in recent times has not been as good as they should be (Ministry of Education Science and Sports, 2007; Ministry of Education Youth and Sports, 2004a). In other contexts, researchers have highlighted the role culture plays in mathematics teaching and learning (Bishop, 1991; Presmeg, 1998; Seah, 2004). This study therefore sought to investigate cultural influences on primary school students' mathematical conceptions and practices in Ghana, as they move between contexts of different mathematical practices between the home (OOSM) and the school (ISM). Two main research issues and seven research questions were posed to guide the study (see Section 2.4). These were:

1. What are the sociocultural influences on Ghanaian students' mathematics learning?

a. Do Ghanaian headteachers', teachers' and students' perceptions of mathematics permit the inclusion of out-of-school cultural notions within the mathematics curriculum?

b. Which language(s) of instruction do Ghanaian primary school students, teachers and headteachers prefer? Why?

c. To what extent does exposure to school mathematical culture affect Ghanaian children's use of out-of-school mathematical practices in the classroom context?

2. What are Ghanaian children's transition experiences between the home and the school contexts and how do these affect their learning in school?

a. What cultural differences do students bring forward in mathematics lesson? How do teachers usually handle them? Why do they handle them the way they do?

b. In what ways do Ghanaian students make use of their knowledge of out-of-school mathematical practices in the classroom context?

c. To what extent do Ghanaian students' preferences for language of instruction reflect their thinking language?

d. To what extent do Ghanaian primary school teachers and parents collaborate in assisting students' mathematics transition?

Questionnaires were administered and responded to by 137 primary school teachers and their headteachers (24), from 25 (out of all 74) primary schools in the Cape Coast Metropolitan area of Ghana. These teachers and their headteachers were selected through the stratified random sampling procedure. This was then followed by 16 focus group interviews with 32 primary school students (four each from grade 4 and grade 6), their teachers and headteachers from four (out the 25) schools. These four focus schools purposely selected from the 25 schools consisted of one above-average achieving school, two average achieving schools, and one below-average achieving school. Documentary evidence of how teachers handled culture differences was also collected. Consent was sought from all research participants before the administration of the research instruments. Consent was also sought from the parents of student participants before the interviews.

The data gathered from the closed ended items in the questionnaire survey were analysed quantitatively through the use of frequency counts and descriptive statistics (means), whilst the open ended items were analysed qualitatively, as were the focus group interviews. The main findings from analysis of the results will be summarised as conclusions in this Chapter. This will be done in the order of the research questions. The Chapter will end with the implications drawn from the conclusions from the results for curriculum development and practices, as well as limitations of the study and implications for future research.

8.1 Conclusions

In this section conclusions from what the study found in relationship to the problem outlined in Section 1.5 will be presented in Sections 8.1.1 and 8.1.2. Conclusions based on the first research issue; “What are the sociocultural influences on Ghanaian students’ mathematics learning?” will be presented in Section 8.1.1 whilst conclusions based on the second research issue, “What are Ghanaian children’s transition experiences between the home and the school contexts and how do these affect their learning in school?” will be presented in 8.1.2.

8.1.1 Socio-cultural Influences on Ghanaian Students’ Mathematics Learning

Perceptions about mathematics, the language of mathematics instruction, and cultural interactions are among the variables that researchers have reported as being capable of influencing students’ learning outcomes in mathematics (see Sections 2.1& 2.2). In this section therefore conclusions regarding research participants’ perceptions about mathematics, language use and preference and influences of the exposure to school mathematics on students’ mathematical conceptions and practices, will be presented.

8.1.1.1 Perceptions about mathematics.

To the research question 1(a): “Do Ghanaian headteachers’, teachers’ and students’ perceptions of mathematics permit the inclusion of out-of-school cultural notions within the mathematics curriculum?” the study concludes that perceptions of students, teachers and headteachers appear to generally permit the inclusion of out-of-school cultural notions in the school mathematics curriculum. The majority of the students recognised out-of-school mathematics (OOSM) also as a form of mathematics, and also acknowledged the importance of OOSM, especially in commerce. Teachers and headteachers perceived links between mathematics pedagogy and the Ghanaian culture. Both headteachers and teachers were of the opinion that OOSM could be used to support students' mathematics learning. However, students identified with school mathematical culture (ISM) despite their recognition of OOSM as a form of mathematics, whilst both the students and the teachers appeared to see ISM as the 'authentic' mathematics. Students identified ISM as the mathematics in the school curriculum, mathematics that is tested, and the mathematics they need for their future. Finally the study found that the school mathematical culture appears to influence students' perceptions about mathematics. Students' perceptions about mathematics reflected those of the headteachers and the teachers.

8.1.1.2 Language preference.

To the research question 1 (b): "Which language(s) of instruction do Ghanaian primary school students, teachers and headteachers prefer? Why?", the study concludes that the English language remains a language which appears to be spoken only within the school premises; the majority of all the research participants said students use the English language mainly when they have lessons in the classroom. English language also remains the language of mathematics generally in the schools. However the majority of the students appeared to have no opportunity to speak the English language at home.

The majority of the students generally preferred to study mathematics in the English language (their weakest language), not necessarily in order to understand mathematics, but to be able to speak English, and also because the English language is the language of the test. Students generally preferred to study their perceived difficult topics such as fractions in the local language (their main/strongest language) for better understanding, whilst they generally preferred to study their perceived easy topics in the English language (weakest language). Some of the lower achieving students, however, generally preferred to learn mathematics in the local language (strongest language) because of the difficulty in understanding lessons in the English language.

Finally, the majority of the teachers preferred students to study mathematics in the English language because it is the approved medium of instruction and also because of examinations. However teachers from the low achieving school preferred their students to study mathematics in either the local language or a mix of the local language and the English language for better understanding of concepts. Whilst half of the headteachers preferred students to study mathematics in only the English language, mainly because it is the medium of instruction and also because of examinations, the remaining half preferred the combination of both the English language and the local language in order to enhance students understanding. Headteachers preference for the language of instruction for mathematics generally differed from that of the teachers. For example, whilst the headteacher of the below average school preferred students to study mathematics in only the English language, the teachers preferred students to study mathematics in the local language or a mix of English and the local language. The reverse was the situation in the above average achieving school, where the headteacher preferred teachers to use both the local language and English language as the medium of instruction in mathematics, but the teachers preferred the use of only English language.

8.1.1.3 Effect of exposure to school mathematical culture on Ghanaian students' use of out-of-school mathematical practices in the classroom context.

To the research question 1(c): "To what extent does exposure to school mathematical culture affect children's use of out-of-school mathematical practices in the classroom context?", the study concludes that exposure to school mathematical culture appeared to influence the use of out-of-school mathematical practices in the identification of halves in school. Not much difference was observed in the way grade 6 and grade 4 students made use of out-of-school mathematical practices in the classroom context. This is probably because of the closeness of the grade levels, however, grade 6 students appeared to be more proficient in the selective use of out-of-school mathematics in school mathematics than grade 4 students.

8.1.2 Ghanaian Students' Transitions between Contexts of Mathematical Practices

As already noted in Chapter Two, researchers have highlighted that learners bring meanings into the learning situation in the mathematics classroom. In this section conclusions from what this study found in the Ghanaian context will be presented.

8.1.2.1 Cultural differences students bring up in mathematics lessons, how teachers handle them and why they handle them the way they do

To the research question 2(a): "What cultural differences do students bring forward in mathematics lesson? How do teachers usually handle them? Why do they handle them the way they do?", the study concludes that the main cultural differences students brought up in the four activities included verbalisation and justification of answers through oral computation, the use of the same fraction name to identify different unit fractions, expressing different unit fractions as half, writing fractions based on local translation of fraction names (exchanging numerators for denominators), sharing according to seniority, use of local unit of measure (instead of measuring scale), division as repeated subtraction, multiplication as repeated addition, decomposition method for adding mixed numbers, finger counting and rounding in measurement.

Teachers handled culture differences by ignoring the culture differences students brought with them in the mathematics lesson and rather concentrated on the school's way of doing mathematics, as prescribed by the school mathematics curriculum. This is mainly because they have to follow the school curriculum upon which students are examined.

8.1.2.2 The ways Ghanaian students make use of their knowledge of out-of-school mathematical practices in the classroom context.

To the research question 2(b): “In what ways do Ghanaian students make use of their knowledge of out-of-school mathematical practices in the classroom context?”, the study concludes that generally practical activities evoked out-of-school thinking whilst paper and pencil activities evoked in-school thinking. Practical activities involving identification of fractions in real life situations and measurement of area in the out-of-school task were approached using out-of-school thinking, whilst a parallel paper and pencil task in the in-school task were approached using in-school thinking.

The local culture influenced students’ conceptions and practices in fractions. All students had difficulty identifying fractions in everyday situations; their notion of fraction in everyday situation influenced their conceptions and practices in fractions in school. The majority of students could identify a half in an everyday situation, but none of them was able to identify a half in paper and pencil activities. Students’ notion of fraction in school was limited to the number of shaded portions divided by the number of partitions in the whole. Fractions remained an abstract school concept to the students, and so were the System International (SI) units. Some students could not read the measuring scale correctly whilst others could not read it at all; in measuring, the students ended up using the local units of measures based on margarine cups.

Context affected ways some students presented solutions to mathematics problems solving. Some students presented solutions to problems solved in the out-of-school context without mathematical equations whilst the same problem was usually solved using mathematical equations in school. Thus mathematical equations were usually used in the in-school activities or activities that were carried out in the school premises.

Also conditions for sharing, as in division in mathematics problem solving, changed in some cases as students obtained more information about those who were sharing. Students shared equally amongst two people once the problem indicated the two were of the same age, otherwise students used out-of-school logic in sharing. Finally, teachers made use of OOSM that supported ISM but not those that conflicted with ISM. 'Good' OOSMs are usually shared in class in some schools.

8.1.2.3 Relationship between Ghanaian students' preferences for language of instruction and their thinking language.

To the research question 2(c): "To what extent do Ghanaian students' preferences for language of instruction reflect their thinking language?" the study concludes that gaps exist between most of the students' language preference and their thinking language. The most common strategy observed amongst students in solving problems included code-switching from English to the local language and back to English when they are presenting their solution.

8.1.2.4 Ghanaian primary school teachers' and parents' influences on students' mathematics transition.

To the research question 2(d): "To what extent do Ghanaian primary school teachers and parents collaborate in assisting students' mathematics transition?" the study concludes that the majority of the schools encourage parents' and teachers' collaboration in students' mathematics transitions. However, parents' and teachers' collaboration in students' mathematics transition become necessary mainly when students have learning difficulties in school mathematics or when they have other problems such as behavioural problems. Teachers' influence in the transition is to offer expert advice to parents, whilst the parents follow the teachers' advice. Also parents' knowledge background inhibits the teachers' collaboration in students' mathematics transitions if the parents are illiterate. Mathematical knowledge of illiterate parents was perceived by some teachers as being inappropriate for helping their children to learn mathematics at school.

8.2 Implications of the Findings

In Section 1.6.2 the importance for the study to policy makers, curriculum developers, teachers, headteachers and researchers was highlighted. In this section the implication of the findings for policy makers and curriculum developers, headteachers and teachers, and teacher educators will be presented.

8.2.1 Implications for Policy Makers and Curriculum Developers

8.2.1.1 Implication for policy makers.

1. In order to avoid the situation where the ISM is seen as the 'authentic' mathematics by students like SX63 and teachers like TL6 (as we saw in Sections 7.1.1.1, p. 303 and 7.1.1.2, p. 306 respectively), policy makers in Ghana must enact policies to ensure that OOSM is given equal political support as ISM (as done elsewhere in South Africa) (see Laridon, Mosimege & Mogari, 2005). This may go a long way towards improving mathematics pedagogy in schools.
2. In order to help low achieving students such as SW44 and SW43 who said they preferred to learn mathematics in the Fante language because they do not understand lessons in English (the language their teacher always uses in teaching mathematics), to be able to understand lessons, the language of instruction policy for schools at the primary level in Ghana could be reviewed to take into account individual student needs. Instead of indicating that the English language should be mainly used as the medium of instruction from grade four onwards (see MOESS, 2008), the policy could be made in such a way that the language use would depend on the linguistic needs of the students. If the students need to be taught in mainly the local language to understand a concept, even in grade 5, they should be taught in it; as the school makes efforts to help the students to improve upon their mastery of the English language since it is the language of testing. This may help to improve students' achievements

in mathematics, as language plays a crucial role in mathematics discourse in classroom (see Setati, 2003, 2005a). Also a growing body of literature has highlighted the importance of the use of students' main language as an additional resource in mathematics teaching and learning (Setati & Adler, 2001; Setati, Adler, Reed & Bapoo, 2002).

3. Based on the finding that parents' knowledge background inhibits parent and teacher collaboration in students' mathematics transition (as we saw in Section 7.2.4), the researcher recommends that as was done in the United State of America by U. S. Department of Education through "The Parent and child Literacy Program" (see Carlson, 1991), the education department in Ghana could also run programmes to resource parents who lack the requisite knowledge and skills to support their children's mathematics transition.

8.2.1.2 Implication for curriculum developers.

1. Mathematics curriculum development at the primary school level should represent both the mathematics within the society (OOSM) and school mathematics (ISM), to avoid the situation where some students perceive only ISM as the written mathematics (as was seen in this study, see Section 7.1.1.1, p.300). This may require an examination and possible adaptation of relevant aspects of the cultural curriculum proposed by Bishop (1988) by the Ministry of Education. By so doing, the curriculum would enculturate students into their own mathematical culture (OOSM) and at the same time acculturates them into the international mathematics culture (ISM). This would enable students to make the connection between the two sets of mathematics and also use the two effectively.
2. To avoid the situation where some students might use the out-of-school logic to solve problems which require them to use the in-school approach (as we saw in Section 6.1.1.1), questions posed in textbooks should be as transparent as possible to students and mathematical assumptions should be clearly stated. Textbook authors should avoid too much adaptation from questions drawn from textbooks abroad. Such questions should be contextualised; such

contextualised questions need to make the necessary mathematical assumptions explicit to students to enable the question to elicit in-school response from students.

3. Curriculum developers including primary school textbook writers should bring in a variety of practical activities to avoid the situation where students use out-of-school logic for practical activities. In developing the concept of fractions for instance, authors should not limit the concreteness of fractions to paper folding (as noted by Freudenthal, 1983), or group of oranges as in fraction as a group (see Wilmot & Ashworth, 2003 for example). They should rather make fractions more practical by bringing in things like a glass of water to avoid situations where students always use a box or a diagram to describe a unit fraction (as was found in this study, see Section 6.3.1.5). None of the popular mathematics textbooks in Ghana, as far as the researcher is aware, has activities which test students' ability to identify unit fractions in a glass or a container for example (see Wilmot & Ashworth, 2003 for example).

8.2.2 Implications for Headteachers and Teachers

8.2.2.1 Implication for headteachers.

The traditional approach of headteachers involving parents mainly in school infrastructure development through PTA's (see Section 2.3) must give way to a more proactive system where parents would be actively (but not passively) involved in students' mathematics transitions between home and school. It was clear from the results of this study that this traditional approach to parent and teacher collaboration where "expert" teachers tell "novice" parents what to do, appeared to show evidence of no impact on students' achievement. Parents should rather be invited by the school authority to the school, not only when their children are having learning difficulties or having problems coping with school mathematics. Parents of both high achieving and low achieving students should be seen as partners in students' mathematics transitions. Headteachers could organise forums, maybe twice or three times in a term where parents of high achieving students and those of the low achieving students and possibly their teachers meet to share experiences. This might go a long way towards helping the parents of the low achieving students to learn how to manage their children's mathematics transition between the home and the school from parents of the high achieving students. As proposed by Ingram, Wolfe, and Lieberman (2007) parents could also be resourced to help their children at home. Headteachers, through their school management committees (SMC's) in Ghana, could find ways of resourcing illiterate parents to engage in school mathematics work with their children at home. This may go a long way to improve students' learning outcomes in mathematics (see Epstein, 2001).

8.2.2.2 Implication for teachers.

1. Cultural differences should not be ignored (as was found in this study, see Section 7.2.4), but they should rather be utilised to scaffold students' higher cognitive thinking. Teachers in Ghana should see beyond students' mistakes, as students' mistakes could be based on another logic system (as it was found in this study, see Section 6.1.1.6). They should make every effort to understand students' misconceptions in order to help students in transitions between contexts of mathematical practices. Finger counting for instance should not be discouraged; it should rather be used to support students' learning in Ghanaian classrooms, as studies have found that finger counting does support students' mathematics learning in school (see Draisma, 2006). The researcher supports Mercer's (1995) suggestion to teachers on how to guide classroom discourse as; "... they have to start from where the learners are, to use what they already know, and help them to go back and forth across the bridge from everyday discourse into educated discourse." (p. 83) Mathematics pedagogy must therefore build on learners' previous knowledge. This implies that elements of both horizontal and vertical mathematization (see Section 1.3) should be clearly seen in mathematics lessons to make mathematics meaningful to students. Here the researcher would propose a three-tier teaching model for Ghanaian students, based on Bishop's (1988) explanation of mathematical enculturation and mathematical acculturation (see Section 2.1.1).

Stage one: would involve enculturating students into their own mathematical culture. In this stage students would go through the out-of-school mathematics in the classroom. In this stage no ISM would be introduced yet. Lessons should involve practical activities as well as paper and pencil activities using only the OOSM, which forms the majority (if not all) of the students' schema (see Hogan, 1995) in mathematics. At the end of this stage students' knowledge of OOSM would have been reinforced. This may go a long way towards changing the perception of students like SW43, who said OOSM is not written (as we saw in Section 6.4.2.1, p. 280).

Stage two: interface between enculturating students into their own mathematical culture (which is predominantly OOSM) and acculturating students into the international mathematics culture (which is predominantly ISM) (Transition stage). In this stage students' attention would be drawn to the local nature of OOSM. This would involve drawing students' attention to what is done elsewhere, and the differences and the similarities to what is done in Ghanaian society. Thus at this stage the teacher prepares the students to accommodate an expansion in their mathematics schema to include ISM.

Stage three: acculturation stage, at this stage students would be introduced to in-school/international mathematics. This would be done by building upon stages one and two. As with stage one, the lesson delivery should involve practical activities as well, but not only paper and pencil activities. Also these practical activities would be discussed using the ISM, as the teacher attempts to guide students to make connections between the OOSM and ISM (i.e. help students to go back and forth across the bridge, in Mercer's words). At the end of this stage students' mathematics schema would have been enlarged to include ISM as well. Stage two and stage three could address the situation whereby students used out-of-school logic for practical activities and in school approaches for paper and pencil activities (as was seen in Section 7.2.2), as well as the practice whereby teachers ignored cultural differences brought up by the students.

The three-tier teaching model draws its theoretical support from Lancy's (1983) cognitive theory, which says that, regarding cognitive development, it is societies rather than individuals which make transitions from one level of cognitive functioning to the other (p. 169). Specifically, the three-tier teaching model draws its strength from the last two stages of Lancy's three-stage theory on cognitive development. The first stage of the three-tier teaching model (enculturating stage) relates to the second stage of Lancy's (1983) cognitive theory, which states that "what happens to cognition during Stage II, then, has much to do with culture and environment and less to do with genetics" (p.205).

Thus stage one of the three-tier teaching model also emphasis the mathematical knowledge within the local culture and the students' environment. The second and the third stages of the three-tier teaching model also have connection with the third stage of Lancy's cognitive development theory, which concerns the metacognitive level. According to Lancy (1983) "They learn what kinds of knowledge are important for what purposes; they learn the relationship between knowledge and status; they learn the appropriate occasions for knowledge acquisition and display; and so forth" (p.208). As was seen from the discussion of the stages in the three-tier teaching model (above), emphasis was also placed on the need to make relationships between the different cultures of mathematics explicit in the meaningful presentation of mathematics to students in stage two and stage three.

The three-tier teaching model may also have implication for the language of instruction. As most (if not all) of the students' mathematics schema are in the local language, the use of the local language may have to form part of the lesson. Thus in each of the three stages the language of instruction could be the local language, or both the English and the local languages, depending on the language needs and the grade level of the students. All technical language of mathematics should be maintained in order to avoid confusion, since unlike other African countries such as South Africa (see Setati, 2005a), in Ghana the mathematics register (see Pimm, 1987) in the local language is not yet developed. Code-switching (see Baker, 1993) would therefore be important in the use of the three-tier teaching model.

Example of the use of the three tier strategy: In teaching fractions for instance, instead of starting with the school notion of halves, thirds and so on using concrete materials such as bread and sticks (see Ministry of Education, 2001), the three-tier model could be used. This could start with the students own notion about halves in Ghanaian culture (stage one; enculturating). This could involve a half as in "fã"(about midpoint) and a half as in "sin"(less than whole) using a real life situation like water in a glass. The next stage (transition stage) may involve drawing students' attention to the problems that the practices of using the same fraction name for different fractions might cause to people who are foreign to Ghanaian culture. Here teachers may draw on Ghana's relationship with the world through trade (international trade), games (World Cup, Olympics) amongst others to justify why foreigners' perspectives may have to be taken into consideration. Students may be given a project to look at how other cultures identify halves, what a half means in other cultures. This stage would usher students into the third stage of the three-tier teaching model. At the third stage (acculturation stage), students would be introduced to the school/international concept of a half by drawing on students' notion of a half from stage one and what they learnt about a half from other cultures of mathematics in stage two (transition stage). At this stage students are guided to the understanding of a half as a midpoint as in international notions of a half (as in ISM). Students may then be introduced to the symbolic representation of a half in school. This could then be followed by naming of the other fractions. Once students are made aware that a half is the midpoint, they could be guided to come out with what one-third would look like amongst other fractions.

Also, instead of taking students through the various SI units of measurement before actual measurement is done, as revealed by HC in Section 6.1.6, the three-tier model could be also used. In order to make measurement more realistic and relevant to students' daily lives, it could start with the use of "a margarine cup," "Olonka," "atuwudu" amongst others in measuring capacities for example (stage one; enculturation). It should also involve operations on these local units of measure, which is currently not seen in any mathematics book in Ghana. The next stage (transition stage) could involve looking at the problems associated with the use of these local units of measures (especially the need for international trade). This would usher the students into the final stage of the three-tier teaching model (enculturation stage), where students would be introduced to the SI units of measures using scales and realistic examples, and their relationship with the local units of measures. By so doing students may be able to apply their school knowledge in the out-of-school setting. For instance, students may be able to tell that one cup of rice is equivalent to about 0.4kg. Also the situation whereby fractions and measurement appear to remain abstract school concepts would be reversed, and this may go a long way towards improving Ghanaian students' performance in mathematics. Like Galperin's systemic instructional principles (as cited in Stetsenko & Arievitch, 2002; p. 95), the three-tier teaching model also attempts to bridge gaps between students' practical knowledge (which is mainly embedded in the OOSM) and theoretical knowledge (which is mainly embedded in the ISM).

The three-tier teaching model could be used in the development of lessons at the entire primary school level, but more especially in grades one to four. In order to avoid undue difficulty for students who may emigrate to another country in future, it may not be advisable to attempt to implement the three-tier teaching model according to grade levels. If a policy is made to implement stage one (enculturating stage) in grades one and two for example, it might create problems for students who may migrate after grade one or two. These students would still have no knowledge about ISM, and that would affect placement of such students in their host countries. Thus, in the opinion of the researcher all three stages come together in a lesson to help students to understand mathematics they learn in school, and make links between the mathematics they learn in school and mathematics in their society. Even though Laridon, Mosimege and Mogari (2005) observed that "teachers responded differently to ethnomathematical pedagogy," (p.138) many researchers have shown that cultural activities improve students' mathematics achievements in the classroom (see Section 2.2.1).

2. As was proposed in Section in 8.2.1.2 for the curriculum developers, teachers should also ensure that problems they pose to students are as realistic as possible. The use of questions from textbooks written abroad should also be done with care. Similarly attempts should be made to make such questions as transparent as possible to students before they are used. Where necessary, more information should be provided to elicit in school responses from students.

3. Teachers should do everything possible to facilitate collaboration with parents in students' mathematics transitions. The traditional approach of suggesting solutions to parents may have to give way to a situation where they would see parents as partners in assisting students' mathematics transitions (see Bishop 2002). This could be in the form of sharing experiences on how the students learn. Teachers also have to look at ways of engaging parents in mathematics learning with their children. This could be in the form of teachers giving home work that has to be solved cooperatively between students and their parents in grades one to four for example. Literature suggests that this improves parents' participation in their children's education (Carlson, 1991; Epstein & Salinas, 2004), which may eventually improve the students learning outcomes in mathematics (see Epstein, 2001).

8.2.3 Implications for Teacher Educators

1. In-service training should prepare teachers on how to handle the technical language of mathematics. This would go a long way towards equipping teachers like TC and TL4 (Sections 6.1.3.2 & 6.2.3.2) with the knowledge of how to teach mathematics meaningfully in the English language by making use of OOSM. It will also equip teachers to be able to teach mathematics in the local language by making use of the technical terms in mathematics.

2. Both in-service and pre-services teacher education programmes must equip teachers to handle cultural differences. In-service teacher training programmes by the Ghana education Service particularly and organisations responsible for the continuous teacher development in Ghana should be tailored to equip practicing teachers with the necessary skills in how to use cultural difference to scaffold students' learning. This would avert the situation where teachers ignore cultural differences by concentrating on what the syllabus says. By so doing, that aspect of horizontal mathematization which is often missing in mathematics teaching in Ghana (see Section 2.1.3) would be evident. This may go a long way towards improving students' learning outcomes in mathematics.

   Pre-service teacher training programmes by Universities and Teacher Training Colleges in Ghana must also be tailored to produce teachers who are knowledgeable about the role of culture in mathematics teaching and learning, as well as teachers who are able to use the culture of students as an asset rather than a liability in their mathematics lessons (see Presmeg, 2007). This may call for the introduction of ethnomathematics programmes (which are not studied in any teacher education programme in Ghana at the moment as far as the researcher knows) in teacher education programmes in Ghana. Prospective teachers at all levels could be introduced to the cultural nature of mathematical knowledge in their curriculum studies courses.

3. A growing body of literature has highlighted the positive impact of teachers' and parents' collaboration in students' mathematics learning on students' mathematics achievement in school (O'toole & Abreu, 2003; Abreu & Cline, 1998; Epstein, 2001; Epstein & Salinas, 2004). The researcher therefore recommends the need for the Ghana education service to educate teachers through in-service and pre-service programmes to engage parents in the learning of mathematics with their children.

Some of the recommendations to the teachers, headteachers and curriculum developers could be applicable to other African countries which also experience one form of mathematics in school and another form of mathematics at home or outside school. For instance, the need to bridge the two sets of mathematics (OOSM and ISM) through policy and practices, as proposed in the three-tier teaching model, is likely to exist in other African countries whose situation is similar to Ghana.

8.3 Limitations of the Study and Implications for Future Research

In this final section (of the thesis) the limitations of the study and implications from the conclusions for future research will be presented. The implication for future research will also include implications of the limitations of the study (Section 8.3.1) and those from the implication of the findings (Section 8.2).

8.3.1 Limitations of the Study

Like any other student project, this project was not without limitations. Due to time constraint the qualitative part of the study, which forms the core of the study, was carried out in only four primary schools. The constraints on time also did not permit the researcher to include other data gathering approaches such as observation of lessons, which could have unearthed more information on what cultural differences students usually bring up in mathematics lessons, and how teachers handled these. Thus, how teachers said they handled cultural differences, for instance, could have been verified by observation of their lessons (on fractions and measurement especially). The constraints on time also made the researcher concentrate on the school; so parents' views were not elicited in this study. Nevertheless, the researcher made efforts to ensure an acceptable level of internal validity which gives credibility to the findings from the study (see Chapters Three and Four).

Also worth mentioning in the limitations of this study, was the occasional use of similar answers by some students in the activities during the focus group interviews (see Section 6.3.1.5, Table 6.3.3, p. 239 for example), and the occasional dominance of active students such as SL42 for example (see Section 6.2.1.1, p. 195). However, in order to ensure that student responses constituted their independent views, the researcher encouraged students throughout the focus group interviews to feel free to give their independent opinion, as the activities were not going to affect their class assessment.

8.3.2 Implications for Future Research

In view of the need to test some of the recommendation made in Section 8.2, specifically the teaching model proposed by the researcher, the need to address the limitations highlighted in Section 8.3.1, and the need for further understanding of some of the findings, the researcher recommends the following future research.

1. Experimental comparative studies need to be carried out in Ghanaian primary schools to ascertain the efficacy, as well as the possible problems that may be associated with the use of the three-tier teaching model proposed by the researcher. This will go a long way towards helping fine tune the proposed teaching model.
2. Further research should be carried out to ascertain how exposure to school mathematical culture influences the use of out-of-school cultural notions in school mathematics. This study could not reveal much, probably because of the closeness of the grade levels.
3. Further research on cultural differences students bring up in the various mathematics concepts and how teachers handle those cultural differences should be carried out through the use of interviews and classroom observation of lessons. This would help to ascertain some of the cultural differences students bring up in the various concepts and how teachers really handle those cultural differences, as the present study could not confirm ways teachers handle cultural differences from observation of mathematics lessons in the classroom (as already noted in Section 8.3.1). Findings from such a

study, if utilized, may go a long way towards informing curriculum development and delivery in Ghana.

4. The literature highlights the importance of explicit teaching of the mathematics language, especially to students whose main language is not English (see Robertson, 2009; Setati, 2005b). Further research should be conducted to investigate whether teachers teach students mathematical language and writing of mathematical language in equation form, as the majority of the students had difficulty presenting their solutions using the appropriate mathematical language and equations (see Sections 6.1.2 and 6.2.2, for example).
5. Studies have found some degree of association between school leadership and students' achievement in general (see Marks, 2003), and school leadership and students' achievement in mathematics specifically (see Heck & Hallinger, 2009). In this study the results revealed that the headteacher of the only above average achieving school (School W) said the school did not encourage parents' and teachers' collaboration in students' mathematics transitions (as was seen in Section 7.2.4). Based on this finding, further research on school culture of the four focus schools, focusing on school administration styles, should be carried out. This will help to unearth some of the input variables that account for the high achievement of students in School W, which rather discouraged parents' and teachers' collaboration in students' mathematics transitions.
6. The issue about the misunderstandings of the intent of the consent forms (see Section 4.5.3) is also worth noting in the implications for future research in developing countries such as Ghana. The researcher's personal experience in Ghanaian society has led to his understanding of this culture as being one which thrives on interpersonal trust. As such, "exotic" research methodologies (such as the need for signed consent by the participants), should be implemented in such a way that, in an attempt to allay fears in the research participants, it would not rather discourage them from participating in the research.

Finally, the researcher would want to end this thesis with some comments from the headteacher of School L (the school with the most culture-free perception about mathematics pedagogy): “I have also enjoyed our conversation; the questionnaires gave us so many things to learn. I personally have learnt a lot, and some of the teachers also said the same thing” (HL). It is the hope of the researcher that not only HL and her teachers learnt through this research, but also teachers like TC and their students (as we saw in the introduction to Chapter One). It is also the hope of the researcher that this study will provide the platform for future dialogue in Ghana on how best to improve students’ mathematics learning outcomes using the sociocultural approach to curriculum development and delivery.

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Appendices

Appendix A - Local units of measures in the Ghanaian local market

A01: “One margarine cup and a half margarine cup”

A02: “An ‘Olonka’ and a margarine cup”

Appendix B - Typical traditional round farm house in Northern Ghana

A modern version of round house in the Northern Ghana

Appendix C - Teachers' questionnaire

Center for Science, Mathematics and Technology Education

Faculty of Education

Monash University, Australia

Title of Research: Cultural Influences on Primary School Students' Mathematical Conceptions in Ghana

QUESTIONNAIRE FOR PRIMARY SCHOOL TEACHERS

This questionnaire seeks information about primary school teachers' conception of "mathematics".Your candid response to this questionnaire is very valuable and will be appreciated. Your response will be treated as confidential and would be used for research purposes only. The findings from this study will help Teacher-Training Institutions to improve upon their Mathematics Education curriculum. It will also inform future curriculum development and delivery in primary schools. Thus, it will go a long way to help improve the teaching and learning of Mathematics in schools.

SECTION A

Teachers' biographical data

1. Name of School …………………………………………………………………
2. Circuit ………………………………………………………………………..
3. District ……………………………………………………………………….
4. Gender (Tick): Male ☐ Female ☐
5. At which level do you teach (tick the one that applies to you)

Lower primary ☐

Upper primary ☐

Other (specify): ………………………………………………………….

6 Age (tick the one that applies to you):

20-29 years ☐

30-39 years ☐

40-49 years ☐

50 years and above ☐

7 Teaching experience (tick the one that applies to you)

5 years or less ☐

6 – 10 years ☐

11 – 15 years ☐

16 – 20 years ☐

21 – 25 years ☐

26 years and above ☐

8 What is your highest academic qualification? (Tick the one that applies to you)

G C E ‘O’ Level ☐

G C E ‘A’ Level ☐

S.S.S.C.E ☐

MSLC ☐

Other (specify): ………………………………………………

9. What is your professional status? (Tick)

Trained teacher ☐ Untrained teacher ☐

10. If you are a trained teacher, what is your highest Professional Qualification?

Bed (Basic Education) ☐

Diploma in Basic Education ☐

Cert "A" 3 year ☐

Cert "A" 4 year ☐

Specialist Programme ☐

Other (specify): ....

11. Indicate by ticking, the highest level at which you studied school Mathematics

Junior Secondary School ☐

Middle School ☐

Senior Secondary School ☐

GCE 'O' Level ☐

GCE 'A' Level ☐

Teacher Training College ☐

Other (specify): ....

<u>SECTION B</u>

Perceptions about "mathematics"

Respond to the statements in the table below based on **YOUR** belief but not what is expected to be the normal situation by ticking (√) in the appropriate box.

	Statement	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
12	Mathematical truth is unquestionable				
13	Doing mathematics requires using rules which has little to do with indigenous culture				
14	Mathematical knowledge is useful				
15	Mathematical knowledge is objective knowledge				
16	Mathematical practices in our indigenous culture can support children's learning in school mathematics				
17	Mathematical knowledge is the same everywhere				
18	Mathematical knowledge has many applications				
19	Mathematical truth is certain				
20	Indigenous culture practices has no place in mathematics				
21	Mathematics has very little relevance to indigenous communities				
22	Mathematics is not free from (moral, ethical, religious etc) values				
23	Mathematical truth is fixed				
24	Language has nothing to do with mathematical thinking				

25	Mathematics is an easy subject				
26	Mathematical truth can be rejected based on sound argument				
27	Every culture makes its own mathematics				
28	Mathematics is interesting				
29	Nature of school mathematics makes the introduction of out-of-school mathematics practices in-school mathematics impossible				
30	Teachers’ knowledge of mathematical practices in learners’ culture may help in mathematics teaching and learning				
31	Children are very likely to understand mathematics better when they are taught in the language they understand best				
32	Mathematics is a difficult subject				
33	Mathematics should be made an optional subject at all levels including primary school level				
34	Mathematical practices differ from culture to culture				

	Statement	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
35	Values such as moral, ethical or religious are present in mathematics teaching				
36	Mathematics is boring				
37	Success in mathematics depends on intellectual ability				
38	Use of out-of-school mathematics practices in school mathematics will facilitate children's understanding of school mathematics				
39	Use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively				
40	Learning mathematics basically requires memorising facts				
41	Mathematics learning is all about practicing a given task over and over again				
42	Teaching mathematics involves active participation of pupils throughout the lesson				
43	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise				

44	Teaching mathematics requires making use of what children already know, including mathematical practices in their homes to help them to understand the lesson				
45	Mathematics should only be studied by bright pupils				
46	Teaching mathematics requires using children's mathematical practices in their culture to help them to understand the lesson				

47. Do you believe that one's cultural practices have a place in mathematics teaching and learning in school? (Tick) yes ☐ no ☐

48. If your answer to question 47 is yes, indicate by ticking which of the topics below allows for inclusion of out-of-school mathematical practices (You may tick more than one).

Measurement ☐

Lines and space ☐

Fractions ☐

Data handling ☐

Game of chance ☐

Operation on numbers ☐

Word problem solving ☐

Other (specify): ……………………………………………………

49. Do you believe that the activities we carry out daily in the society generates "mathematics" which may not be the same as the school mathematics? (Tick)

yes ☐ no ☐

50. If your answer to question 49 above is yes, which of the following activities in your opinion may generate "mathematics" (you may tick more than one)

Counting ☐

Measurement ☐

Locating ☐

Playing ☐

Designing ☐

Explaining ☐

Other (specify): ……………………………………………….

51. If your answer to question 49 above is no, why not

………………………………………………………………………………..

…………………………………………………………………………………

………………………………………………………………………………….

………………………………………………………………………………….

52. What comes into your mind when someone mentions 'mathematics' to you?

…………………………………………………………………………………

…………………………………………………………………………………

53. Briefly explain what mathematics means to you?

………………………………………………………………………………….

………………………………………………………………………………….

…………………………………………………………………………………

54. The National Festival of Arts and Culture (NAFAC) was celebrated in November 2007 in Kumasi as a way of preserving our rich Ghanaian culture. Do you believe mathematics education can also be a vehicle for the preservation of our rich culture? (Tick) yes ☐ no ☐

55. Give reason(s) for your answer to question 54 above

…………………………………………………………………………………

……………………………………………………………………………….

……………………………………………………………………………….

…………………………………………………………………………………

Thank you

Appendix D - Headteachers' questionnaire

Center for Science, Mathematics and Technology Education

Faculty of Education

Monash University, Australia

Title of Research: Cultural Influences on Primary School Students' Mathematical Conceptions in Ghana

<u>QUESTIONNAIRE FOR HEADTEACHERS</u>

This questionnaire seeks information about headteachers' conception of "mathematics". Your candid response to this questionnaire is very valuable and will be appreciated. Your response will be treated as confidential and would be used for research purposes only. The findings from this study will help improve Mathematics Education curriculum at the teacher training institutions in the country. It will also inform future curriculum development and delivery at the primary school level in the country. Thus, it will go a long way to help improve the teaching and learning of mathematics in schools.

SECTION A

Headteachers' biographical data

1. Name of School: …………………………………………………………
2. Circuit …………………………………………………………..
3. District ……………………………………………………….

4. Gender (Tick): Male ☐ Female ☐

5. Age (tick the one that applies to you):
   Less than 35 years ☐

   35-44 years ☐

   45-54 years ☐

   55 years and above ☐

6. For how long have you been employed as headteacher

   5 years or less ☐

   6 – 10 years ☐

   11 – 15 years ☐

   16 – 20 years ☐

   21 – 25 years ☐

   26 years and above ☐

7. Do you have any teaching experience? (Tick)Yes☐ no ☐

8. If you answered yes to question 7, for how long have you taught (tick the one that applies to you)

   5 years or less ☐

   6 – 10 years ☐

   11 – 15 years ☐

   16 – 20 years ☐

   21 – 25 years ☐

   26 years and above ☐

9. What is your highest academic qualification? (Tick the one that applies to you)

G C E ‘O’ Level ☐

G C E ‘A’ Level ☐

S.S.S.C.E ☐

MSLC ☐

Other (specify): ……………………………………………

10. Were you trained as a teacher? (Tick) yes ☐ no ☐

11. If you were trained as a teacher, what is your highest Professional Qualification?

Bed (Basic Education) ☐

Diploma in Basic Education ☐

Cert “A” 3 year ☐

Cert “A” 4 year ☐

Specialist Programme ☐

Other (specify): ………………………………………………………………….

12. Indicate by ticking, the highest level at which you studied school Mathematics

Junior Secondary School ☐

Middle School ☐

Senior Secondary School ☐

GCE “O” Level ☐

GCE “A” Level ☐

Teacher Training College ☐

Other (specify): ……………………………………………………………………

SECTION B

Perceptions about "mathematics"

Respond to the statements in the table below based on **YOUR** belief but not what is expected to be the normal situation by ticking (√) in the appropriate box.

	Statement	**Strongly agree**	**Agree**	**Disagre**	**Strongly disagree**
13	Mathematical truth is unquestionable				
14	Doing mathematics requires using rules which have little to do with indigenous culture				
15	Mathematical knowledge is useful				
16	Mathematical knowledge is objective knowledge				
17	Mathematical practices in our indigenous culture can support children's learning in school mathematics				
18	Mathematical practices is the same everywhere				
19	Mathematical knowledge has many applications				
20	Mathematical truth is certain				
21	Indigenous culture practices has no place in mathematics				

22	Mathematics has very little relevance to indigenous communities				
23	Mathematics is not free from (moral, ethical, religious, etc) values				
24	Mathematical truth is fixed				
25	Language has nothing to do with mathematical thinking				
26	Mathematics is an easy subject				
27	Mathematical truth can be rejected based on sound argument				
28	Every culture is capable of making its own mathematics				
29	Mathematics is interesting				
30	Nature of school mathematics makes the introduction of out-of-school mathematical practices in school mathematics impossible				
31	Teachers' knowledge of mathematical practices in learners' culture may help in mathematics teaching and learning				
32	Children are very likely to understand mathematics better when they are taught in the language they understand best				
33	Mathematics is a difficult subject				
34	Mathematics should be made an optional subject at all levels including primary school level				

35	Mathematical practices differ from culture to culture				
36	Values such as moral, ethical or religious are present in mathematics teaching				
37	Mathematics is boring				
38	Success in mathematics depends on intellectual ability				
39	Use of out-of-school mathematics practices in school mathematics will facilitate children's understanding of school mathematics				
40	Use of out-of-school mathematics practices in school mathematics will better equip children to use out-of-school mathematics more effectively				
41	Learning mathematics basically requires memorising facts				
42	Mathematics learning is all about practicing a given task over and over again				
43	Teaching mathematics involves active participation of pupils throughout the lesson				
44	Learning mathematics is all about ensuring accuracy in the application of algorithms in class exercise				
45	Teaching mathematics requires making use of what children already know.				

46	Mathematics should only be studied by bright pupils				
47	Teaching mathematics requires using children's mathematical practices in their culture to help them to understand the lesson				

48. Do you believe that one's cultural practices have a place in mathematics teaching and learning in school? (Tick) yes ☐ no ☐

49. If your answer to question 48 is yes, indicate by ticking which of the topics below allows for inclusion of out-of-school mathematical practices (You may tick more than one)

Measurement ☐

Lines and space ☐

Fractions ☐

Data handling ☐

Game of chance ☐

Operation on numbers ☐

Word problem solving ☐

Other (specify): …………………………………………………

50. Do you believe that the activities we carry out daily in society generates "mathematics" which may not be the same as the school mathematics? (Tick)

yes ☐ no ☐

51. If your answer to question 50 above is yes, which of the following activities in your opinion may generate “mathematics” (you may tick more than one)

Counting ☐

Measurement ☐

Locating ☐

Playing ☐

Designing ☐

Explaining ☐

Other (specify): …………………………………………….

52. If your answer to question 50 above is no, why not?

……………………………………………………………………………..

………………………………………………………………………………

……………………………………………………………………………….

……………………………………………………………………………….

53. What comes into your mind when someone mentions ‘mathematics’ to you?

………………………………………………………………………………

………………………………………………………………………………

54. Briefly explain what mathematics means to you?

……………………………………………………………………………….

…………………………………………………………………………………….

55. The National Festival of Arts and Culture (NAFAC) was celebrated in November 2007 in Kumasi as a way of preserving our rich Ghanaian culture. Do you believe mathematics education can also be a vehicle for the preservation of our rich culture? (Tick) yes ☐ no ☐

56. Give reason(s) for your answer to question 55 above

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

………………………………………………………………………………………

Thank you

Appendix E - Headteachers' interview guides

E01: Interview Guide for Headteachers (Stage 1)

Part I

Biographical data (to be filled by the interviewer)

1. Name of School
2. School type
3. Gender
4. For how long have you been employed as a headteacher
5. For how long have you been employed as a headteacher in this school
6. Teaching experience (if any)
7. Professional status
8. Highest professional qualification

Part II

1. Tell me about your school's language policy and language use generally
2. Tell me about parents' participation in the school activities including demonstration by parents in classroom activities
3. As a headteacher you have the sole responsibility of endorsing what the teacher must teach in the classroom in Ghanaian schools. Tell me about use/non use of out-of-school cultural notions by the teachers in mathematics in your school
4. What do you think about the use of out-of-school cultural notions in mathematics
5. What do you think about the use o out-of-school cultural notions in mathematics at the lower primary, upper primary and Junior High School (JHS) levels
6. What do you think about out-of-school "mathematics" in the Ghanaian society such as "pole" as a unit of measure of land, "Olonka" as a unit of measure of grains, "pon" as a system of counting etc

E02: Interview Guide for Headteachers (Stage II)

Part I

Biographical data (to be filled by the interviewer)

1. Name of School
2. School type
3. Gender
4. For how long has the head been employed as a headteacher
5. For how long has the head been employed as a headteacher in this school
6. Teaching experience (if any)
7. Professional status
8. Highest professional qualification

Part II

Language use and preference

Questions:

1. What language do pupils usually use in the classroom when there is mathematics lesson?
2. What language do pupils usually use in classroom when there is no mathematics lesson?
3. What language do pupils usually use when they are outside classroom during break time?
4. What language do teachers usually use in teaching mathematics?
5. What language would you prefer teachers to use in teaching mathematics? Why?
6. Are you aware that from primary four teachers are expected to use English language in teaching mathematics and all other subjects except Ghanaian language?
7. How does that affect teachers' inclusion of out-of-school cultural notions in their mathematics teaching in school?

Part III

Use of out-of-school mathematics in school mathematics

How do your teachers usually make use of out-of-school mathematical notions in their mathematics lessons?

Part IV

Transition experiences

Questions:

1. (a) What are some of the cultural differences that pupils bring forward during mathematics lessons?
   (b) How do teachers usually handle them?

   (c) Why do you think they handle them the way they do?

2. (a) In what ways does the school encourage teachers to collaborate with parents to help pupils' mathematics learning? (NB: If there is no collaboration, continue with question (d) below)
   (b) Why does the school see the need for teacher-parent collaboration in pupils' mathematics learning?

   (c)When does it become necessary for the school to encourage teachers to collaborate with parents to help child's mathematics learning in school?

   (d) If the school does not encourage collaboration between parents and teachers in pupils mathematics learning, why not?

Appendix F - Interview Guide for Primary School Teachers

Part I

Biographical Data (interviewer to fill in)

1. Name of School
2. School type
3. Gender
4. Class
5. Teaching experience
6. Professional status
7. Highest professional qualification

Part II

Language use and preference

Questions:

1. What language do pupils usually use in the classroom when there is a mathematics lesson?
2. What language do pupils usually use in classroom when there is no lesson?
3. What language do pupils usually use when they are outside classroom during break time?
4. What language do you use in communicating with pupils in class when there is no lesson?
5. What language do you use in communicating with pupils outside classroom during break time?
6. What language do you use in communicating with pupils when you meet them outside the school premises?
7. What language would you prefer the children to use in classroom during mathematics lesson? Why?
8. What language do you usually use in teaching mathematics?
9. What language do you usually use in teaching fractions? Why?
10. What language do you usually use in teaching measurement? Why?
11. What language would you prefer to use in teaching mathematics? Why?
12. What language would you prefer to use in teaching fractions? Why?
13. What language would you prefer to use in teaching measurement? Why?

Part III

Use of out-of-school mathematics in classroom context

Questions:

1. We measure in the local market using local units of measure such as empty tins, in what ways do pupils make use of this out-of-school/everyday knowledge in lessons on measurement?
2. How does their knowledge of out-of-school mathematical practices affect (interfere with/support) their learning in school?
3. Sharing is part of pupils' culture; they shared things before they even started formal schooling. In what ways do pupils make use of this out-of-school/everyday mathematical knowledge in lesson on fractions?
4. How does that affect (support/interfere) their learning?
5. In what ways do you make use of out-of-school/everyday mathematics practices in pupils' local culture in your teaching?
6. Are you aware that from primary four teachers are expected to use English language in teaching mathematics and all others subjects except Ghanaian language?
7. How does that affect the inclusion of out-of-school cultural notions in your mathematics teaching in school?

Part IV

Transition experience

Questions:

1. (a) What are some of the cultural differences that pupils bring forward during mathematics lessons?
   (b) How do you usually handle them?

   (c) Why do you handle them the way you do?

2. (a) Do you collaborate with parents to help pupils' mathematics learning?
   (b) If you do, why do you do it? When does it become necessary for you to do it?

   (c)How do you do it?

   (d) If you do not do it, why don't you collaborate with parents to support pupils' mathematics learning?

Appendix G - Students' interview guides

G01: Interview Guide for Children (Home)

Part I

Biographical Data (interviewer to fill in)

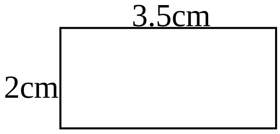
1. Name of pupil
2. Name of school
3. School type
4. Class
5. Achievement level
6. Gender
7. Age

Part II

Transition experience: How children experience mathematics between contexts

Mathematical concepts	Out-of-school task	In school task
Fractions-identifying and comparing fractions. The purpose of these tasks is to find out how children: (a) Identify fractions (b) Compare fractions	**Task I**: Give children two identical containers. Put one-sixth full of water in one and one-fifth full of water in the other. Ask children to; (a) describe/name the amount of water in each of the two containers (b) represent the amount of water in each container in symbol/word (c) tell which is more? **Task II**: Fill one container up to the middle (half full) and put	1. (a) Draw diagrams showing; i) $\frac{1}{5}$ and $\frac{1}{6}$ and ask children to identify ii) $\frac{1}{2}$ and $\frac{3}{5}$ and ask children to identify Use "=" "<" or ">" to complete each of the following.

	three-fifth full of water in the other and ask children to; (a) describe/name the amount of water in each of the two containers (b) represent the amount of water in each container in symbol/word (c) tell which is more?	(b) $\frac{1}{5}$ …. $\frac{1}{6}$ (c) $\frac{3}{6}$ …… $\frac{3}{5}$ **NB**: Ask children to explain their choice using diagrams or oral explanation
Fractions-sharing/division, multiplication of fractions/ Measurement of capacity. The purpose of these tasks is to find out how children. (a)Divide mixed fractions (b)Multiply mixed fractions, through local measuring activity	**Task III**: Give children a container containing ten and half margarine cups full of maize and ask them to share among three children who assisted on a farm. Ask children to: (a) measure, and tell the total amount of maize (NB: Margarine cup is visible and accessible to them) (b) tell how much each child will get (c) represent their solution on paper **NB**: The local units are; Two half margarine cups = one margarine cup Six and half margarine cups =	2. (a) Give children a given quantity of rice (10.5kg). Ask children to: (i) measure (ii) share equally among three people NB: Margarine cup and measuring scale with interviewer in a bag underneath the table. Ask them to feel free to request for anything they need to measure

	one "Olonka" Two "Olonka" = one rubber **Task IV**: Give children "Olonka" full of rice. Tell them that was the share of a boy who shared a given quantity of rice equally with two other boys. Ask them to find total amount of margarine cups of rice that the three boys shared. **NB**: Remind them that one "Olonka" is six and half margarine cups.	2. (b) Ama bought 5.5kg of rice whilst Esi bought three times the quantity of rice Ama bought. What quantity of rice did Esi buy?
Fractions-addition/ Measurement-area. The purpose of this activity is to find out how children add fractions through a local activity of measuring area	**Task V**: Give children 12cmx12cm square and tell them to assume that represent a pole of land. Give them a rectangular shape that is 27cm by 24cm. Tell them they should imagine that to be citrus farm. Ask them to find how many poles are there in that farm. **NB**: A pole is a local unit of measuring farmland by farmers. This is usually 36ft by 36ft square area (i.e. 1296sq ft)	3. (a) Papa Kojo gave Abena $\frac{1}{4}$ of an orange and Ekua $\frac{2}{4}$ of the orange. How much orange did Papa Kojo give to the Abena and Ekua altogether? (b) Find the area of the figure below 

1. Implement all out-of-school tasks in local language and in-school task in English language

2. Take note of the following:
   (a) children's processes and ask to them explain their strategies as they solve the problems
   (b) how they handle the units of measurement
   (c) language they use in communicating among themselves

3. Ask children to tell the language they use in thinking as they go through their processes in solving the problem

Part III

Perceptions about mathematics

Questions:

1. Show children the following pictures from publicly available sources such as magazines or news papers:
   (a) a local market woman selling rice
   (b) a butcher
   (c) an engineer
   (d) driver's mate
   (e) a farmer measuring a plot of land
   (f) a primary school teacher teaching
   (g) a Kente/twil weaver
   (h) a banker
   (i) a medical doctor
   (j) a computer programmer

2. Ask children to predict which of them;
   (a) uses mathematics

Part IV

Language use and preference

Questions:

1. What language do you usually use at home when you are talking with your parents?
2. What language do you usually use at home when you are playing with your friends?

3. What language do you usually use in communicating with the teacher and your classmates in the classroom when there is a mathematics lesson?
4. What language do you usually use in communicating with the teacher and your classmates in the classroom when there is no mathematics lesson?
5. What language do you usually use in communicating with the teacher and your classmate outside the classroom during break time?
6. What language does your teacher usually use in teaching mathematics?
7. What language does your teacher usually use in teaching fractions?
8. What language does your teacher usually use in teaching measurement?
9. What language would you prefer your teacher to use in teaching mathematics? Why?
10. What language would you prefer your teacher to use in teaching fractions? Why?
11. What language would you prefer your teacher to use in teaching measurement? Why?

G02: Interview Guide for Children (School)

Part I

Biographical Data (interviewer fills in)

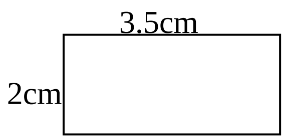
1. Name of pupil
2. Name of school
3. School type
4. Class
5. Achievement level
6. Gender
7. Age

Part II

Transition experience: How children experience mathematics in school

Mathematical concepts	Out-of-school task	In school task
Fractions- identifying and comparing fractions. The purpose of these tasks is to find out how children: (b) Identify fractions (b) Compare fractions	**Task I**: Give children two identical containers. Put one-sixth full of water in one and one-fifth full of water in the other. Ask children to; (a) describe/name the amount of water in each of the two containers (b) represent the amount of water in each container in symbol/word (c) tell which is more? **Task II**: Fill one container up to the middle (half full) and put three-fifth full of water in the	1. (a) Draw diagrams showing; i) $\frac{1}{5}$ and $\frac{1}{6}$ and ask children to identify each f them ii) $\frac{1}{2}$ and $\frac{3}{5}$ and ask children to identify each f them Use “=” “<” or “>” to complete each of the

	other and ask children to; (a) describe/name the amount of water in each of the two containers (b) represent the amount of water in each container in symbol/word (c) tell which is more?	following. (b) $\frac{1}{5}$ …. $\frac{1}{6}$ (c) $\frac{3}{6}$ …… $\frac{3}{5}$ **NB**: Ask children to explain their choice using diagrams or oral explanation
Fractions-sharing/division, multiplication of fractions/ Measurement of capacity. The purpose of these tasks is to find out how children. (a)Divide mixed fractions (b)Multiply mixed fractions, through local measuring activity	**Task III**: Give children a container containing 10.5 margarine cups full of maize and ask them to share among three children who assisted on a farm. Ask children to: (a) measure, and tell the total amount of maize (NB: Margarine cup is visible and accessible to them) (b) tell how much each child will get (c) represent their solution on paper **NB**: The local units are; Two half margarine cups = one margarine cup	2. (a) Give children a given quantity of rice (10.5kg). Ask children to: (i) measure (ii) share equally among three people NB: Margarine cup and measuring scale with interviewer in a bag underneath the table. Ask them to feel free to request for anything they need to measure

	Six and half margarine cups = one “Olonka” Two “Olonka” = one rubber **Task IV**: Give children “Olonka” full of rice. Tell them that was the share of a boy who shared a given quantity of rice with two other boys. Ask them to find total amount of margarine cups of rice that the three boys shared. **NB**: Remind them that one “Olonka” is six and half margarine cups.	2. (b) Ama bought 5.5kg of rice whilst Esi bought three times the quantity of rice Ama bought. What quantity of rice did Esi buy?
Fractions- addition/ Measurement- area. The purpose of this activity is to find out how children add fractions through a local activity of measuring an area	**Task V**: Give children 12cmx12cm square and tell them to assume that represent a pole of land. Give them a rectangular shape that is 27cm by 24cm. Tell them they should imagine that to be an area of a citrus farm. Ask them to find how many poles are there in that farm. **NB**: A pole is a local unit of measuring farmland by farmers. This is usually 36ft by 36ft square area (i.e. 1296sq ft)	3. (a) Papa Kojo gave Abena $\frac{1}{4}$ of an orange and Ekua $\frac{2}{4}$ of the orange. How much orange did Papa Kojo give to the Abena and Ekua altogether? (b) Find the area of the figure below 

1. Implement all out-of-school tasks in local language and in-school task in English language
2. Take note of the following:

(a) Children’s processes and ask them to explain their strategies as they solve the problem
(b) How they handle the units of measurement
(c) Language they use in communicating among themselves

3. Ask children to tell the language they use in thinking as they go through their processes in solving problems

Part III

Perceptions about the relationship between out-of-school mathematics and school mathematics:

1. Enquire from children, their perception about the mathematics they solved using local units of measurements and those they solved at school using metric system
2. Enquire from them their perception about the relationship between the two sets of mathematical practices
3. Enquire from them which of the two sets of mathematical practices in their opinion is important and why
4. Enquire from them which group of people in the society are associated with the two sets of mathematics and why

Part IV

Children’s perceptions about parents’ knowledge:

1. Ask children whether any of their parents/guardians could speak English
2. Ask children whether they receive any support from their parent with their mathematics homework, ask them to elaborate on their response; for instance explain why parent does not support if a child says no or how often parents support with mathematics homework if child answers yes.
3. Enquire from children about their perception about their parents mathematical practices i.e. how similar or different is it from what they learn in school
4. Their perception about the value or worth of their parents’ mathematical practices

Appendix H - Students' worksheets

H01: Children's worksheet (out-of-school task)

Out-of-school task

Worksheet

Class …………………..

Task I

(a) Describe/name the amount of water in each of the two containers

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

(b) Represent the amount of water in each container in symbol(s)/word(s)

……………………………………………………………………………………..

……………………………………………………………………………………..

……………………………………………………………………………………

……………………………………………………………………………………

(c) Tell which is more?

……………………………………………………………………………………

Task II

(d) Describe/name the amount of water in each of the two containers

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

(e) Represent the amount of water in each container in symbol(s)/word(s)

(f) Tell which is more?

…………………………………………………………………………………………

Task III

Share the given maize among three children who assisted on a farm

(a) Measure and tell the total amount of maize

…………………………………………………………………………………………

…………………………………………………………………………………………

(b) Share the maize among the three children and tell how much each child will get

(c) Write your solution on the worksheet

Task IV

This “Olonka” full of rice was the share of a boy who shared a given quantity of rice with two other boys. Find the total number of margarine cups of rice that the three boys shared?

Task V

How many “poles” are there in the area of the citrus farm?

H02: Children's worksheet (in-school task)

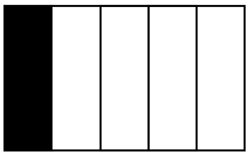
In-school task

Worksheet

Class ……………………………….

1. (a) Write the fraction of the shaded portion in each of the diagrams below

i)



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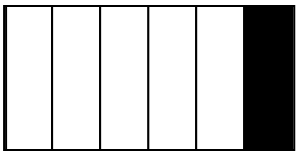
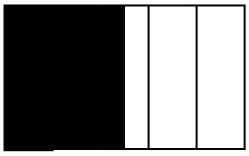


………………………………………………………………………..

ii)



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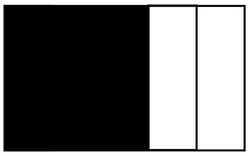


………………………………………………………………………

1 (b) Use “=” “<” or “>” to complete each of the following

i) 1/5 ………….1/6

ii) 3/6…………..3/5

2 (a) i) How much rice is in the container?

Answer: ………………………………………

iii) Share the quantity of rice in 2(a) i) above equally among three people

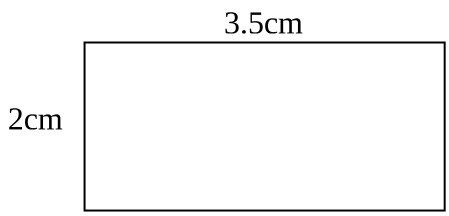
iv) How much will each one of them get?

………………………………………………………………………

2 (b) Ama bought 5.5kg of rice whilst Esi bought three times the quantity of rice Ama bought. What quantity of rice did Esi buy?

3. (a) Papa Kojo gave Abena ¼ of an orange and Ekua 2/4 of an orange. How much orange did Papa Kojo give to Abena and Ekua altogether?

(b) Find the area of the figure below



Appendix I - Ethics approval letter

MONASH University

Standing Committee on Ethics in Research Involving Humans (SCERH)
Research Office

Human Ethics Certificate of Approval

Date:	**22 May 2008**
Project Number:	**CF08/0661 - 2008000302**
Project Title:	**Cultural influences on primary school students' mathematical conceptions in Ghana**
Chief Investigator:	**Dr Wee Seah**
Approved:	**From: 22 May 2008 to 22 May 2013**

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained and a copy forwarded to SCERH before any data collection can occur at the specified organisation. **Failure to provide permission letters to SCERH before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research.**
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by SCERH.
4. You should notify SCERH immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project:** Requires the submission of a Request for Amendment form to SCERH and must not begin without written approval from SCERH. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. SCERH should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by SCERH at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Ben Canny
Chair, SCERH

Cc: Prof Alan John Bishop; Ernest K Davis

Postal – Monash University, Vic 3800, Australia
Building 3E, Room 111, Clayton Campus, Wellington Road, Clayton
Telephone +61 3 9905 5490 Facsimile +61 3 9905 1420
Email scerh@adm.monash.edu.au www.monash.edu/research/ethics/human/index/html
ABN 12 377 614 012 CRICOS Provider #00008C

Appendix J - Letters from Ghana Education Service

J01: Permission letter from the Ghana Education Service

GHANA EDUCATION SERVICE

REPUBLIC OF GHANA

In case of reply the number and date of this *letter should be quoted*

Regional Education Office
P. O. Box 111,
Cape Coast,

My Ref. No GES/CR/352/SF.3A/I/67

21ST December, 2007.

Your Ref. No.....................................

PERMISSION TO CONDUCT A RESEARCH IN CENTRAL REGION

Permission is granted to Mr. Ernest Kofi Davis of Faculty of Education, Monash University, Australia, to do a research in the Primary Schools of Districts of the Central Region of Ghana for his Doctorate Degree.

We hope he would be given the necessary assistance, please.

[redacted]

EBO G. EDZIE
DEPUTY DIRECTOR
for: REGIONAL DIRECTOR OF EDUCATION,
CENTRAL.

All District Directors of Education,
CENTRAL REGION.

J02: Letter from the Central Regional Director of Education

GHANA EDUCATION SERVICE

In case of reply the number and date of this letter should be quoted.

Regional Education Office,
P. O. Box 111,
Cape Coast.

Republic of Ghana

My Ref. No.: GES/CR/352/SF.3A/1/70

Your Ref. No.: ....

16 April, 2008.

The Humans Ethics Officer
Standing Committee on Ethics in Research
Involving Humans (SCERH)
Building 3e Room 11
Research Office
Monash University VIC 3800

RE: COMPLAINING PROCESS IN RESEARCH PROJECT ON "CULTURAL INFLUENCES ON PRIMARY STUDENTS' MATHEMATICAL CONCEPTIONS IN GHANA"

This is to inform your outfit that I agree to take the responsibility of receiving and passing on complaints from research participants in the research project - which is being conducted by Mr Ernest Kofi Davis of Monash University in Australia to the Standing Committee on Ethics in Research (SCERH), Monash University.

Thank you.

[redacted]

Rosemond N. Blay (Ms)
Regional Director of Education
Central Region
Phone -Office: +23342322333
Mobile: +233244698190

Appendix K -A sample of interviews with students

Class: Six

School: School W

Context: School

Participants: SW61 (LA), SW62 (HA), SW63 (LA), SW64 (HA)

Gender: Male, Male, Female, Male

Age: 13years, 15years, 19years, 16years

Date: 13/11/2008

Out-of-School Task

Task I

R: Describe/name the amount of water in this Glass [puts Glass A1 before children]

SW61: sir quarter

SW62: sir quarter

R: Do you all agree that it is a quarter?

S: yes sir [chorus]

R: Now describe the amount of water in this one [at this stage the researcher puts Glass B1 before children]

SW63: quarter

R: Do you all agree with a quarter?

S: yes sir [chorus]

R: Represent the amount of water in each container in symbol(s)/word(s)

SW64: [writes for Glass A1 quarter, $\frac{2}{4}$ and for Glass B1 writes quarter, $\frac{2}{4}$]

SW63: [shook the head in disagreement with SW64's presentation; she wrote $\frac{1}{4}$]

Glass A1 Glass B1

quater wrong quater

$\frac{2}{4}$ $\frac{2}{4}$ $\frac{1}{4}$ $\frac{1}{4}$

R: Tell which is more? [Researcher puts Glasses A1 and B1 with their contents before students]

S: Glass B [referring to Glass B1] [chorus]

SW63: [writes Glass B]

(c) Tell which is more?

Glass B wrong

Task II

R: Describe/name the amount of water in the Glass [puts Glass A2 before children]

SW61: sir half

SW62: sir half

SW63: sir half

SW64: half

R: describe the amount of water in this one too [at this stage the researcher puts Glass B2 before children]

SW62: half quarter; half and a quarter, sir midpoint and a little

SW61: half quarter

SW63: half

SW64: half

R: Represent the amount of water in each container in symbol(s)/word(s)

S: [present answers to Glass A2 and Glass B2 as shown below]

Glass A2 Glass B2

Glass A Glass B half and quate
Half Half
Wrong

Represent the amount of water in each container in symbol(s)/word(s)

$\frac{1}{2}$ $\frac{1}{2}$ and $\frac{2}{4}$

R: Tell which is more? [Researcher puts the Glasses A2 and B2 with their contents before students]

S: sir Glass B [referring to Glass B2], [chorus]

SW63: [writes Glass B]

(f) Tell which is more?
Glass B

Task III

R: [Presents the maize in a bag to the children and keeps scale and local unit of measure in a box; both of them visible to the children, asks children to measure and share it among three people, and asks children to feel free to request for any measuring instrument(s)]

S: sir margarine “konko” [sir margarine tin in English] [chorus]

R: Provides students with a margarine cup

SW63: [Puts three empty containers on a table, using the margarine cup as a unit of measure, with the help of the others, she puts one cup of maize in each container. She (SW63) goes round the second, and third times. Students discuss …. after which she adds half cup on each of the three containers, the whole thing gets finished].

R: How much did each of them get?

S: three and half [chorus]

R: what is the total amount of maize in the container?

S: [orally say] it is ten and half [chorus]

R: Explain your solution to me

SW63: [explains in the local language] sir the maize was ten and half and we shred it amongst three people and each had three and half

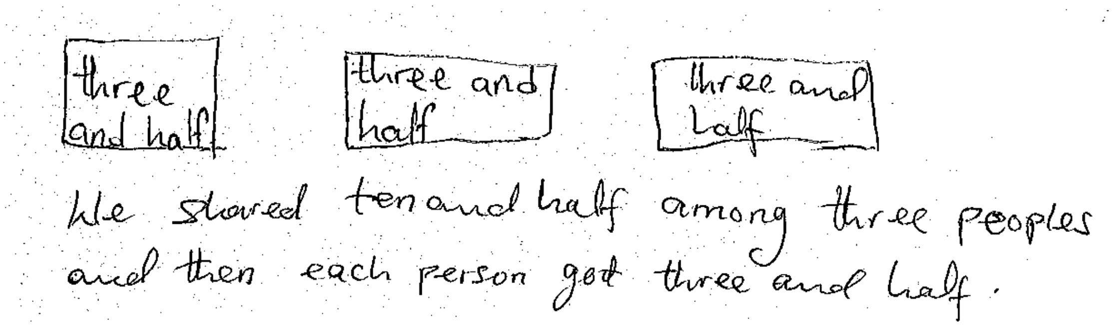
R: How did you share it?

SW61: [explains in the local language] sir when we measure one margarine cup we put in one container, and one in another and one in another; we did that three times, what was left we shared it half, half

R: write your solution in your worksheet

SW64: [draws three containers and write three and half in each of them]

SW62: [goes on further to explain their process by writing we shared ten and half among three peoples and then each person got three and half as shown below]



Task IV

R: This “Olonka” full of rice was the share of a boy who shared a given quantity of rice with two other boys. Find the total number of margarine cups of rice that the three boys shared?

S: nineteen and half [chorus]

R: present your solution on the worksheet for me

SW62: [orally explains the solution as six times three plus one and half will give us nineteen and presents the group’s solution as shown]

$6 \times 3 + \frac{1}{2} = 19$ and $\frac{1}{2}$

method is wrong
but the answer is correct.

R: SW62 what is that? [Points at plus half in six times three plus half]

SW62: sir one and half

S: sir it is one and half [chorus]

Task V

R: How many “poles” are there in the area of the citrus farm? [Presents a 27cm by 24cm paper representing the citrus farm and a 12cm by 12cm square paper representing a “pole” of land to children]

S: [measure the area using the 12cm by 12cm square; they measure the four “poles” and say sir we have finished]

R: what did you get?

SW62: sir four and half “poles”

SW63: sir four and quarter “poles”

SW61: four and quarter

SW64: four and quarter

R: why do you think it is a quarter?

SW64: what is left is not up to one “pole”

SW63: it is neither a half “pole”

R: so what is the area of the farm?

S: four and quarter [chorus]

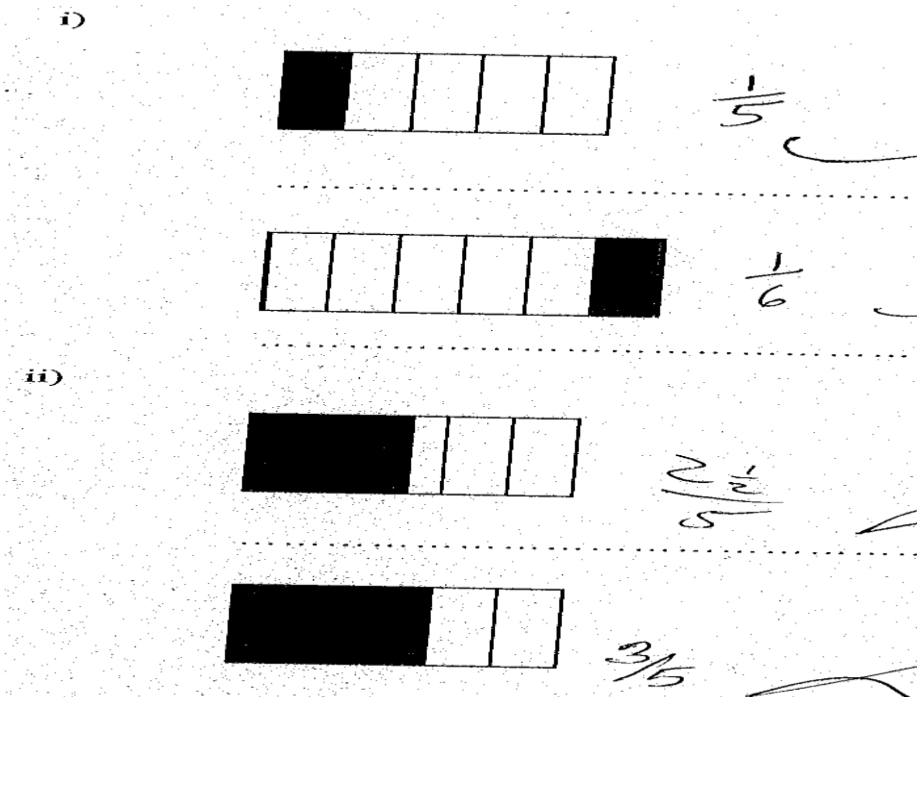
SW63: [presented the group’s solution as four and quarter] four and quater Wrong

In-school Task

Question 1 (a) Write the fraction of the shaded portion in each of the diagrams below

R: Read the question and do it

S: [read the in chorus question, count the total number of divisions and the number of shaded portion(s) in each of the questions, and write the total number of divisions as the denominator and the number of shaded portion(s) as the numerator to get the fraction, as shown below]



Question1 (b) Use “=” “<” or “>” to complete each of the following

R: Read the next question [Question 1 (b)] and do it

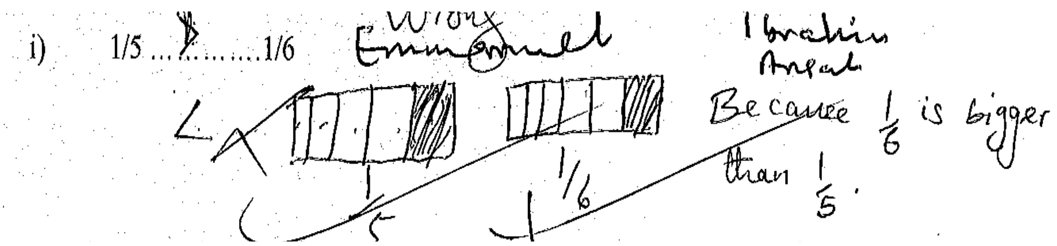
SW64: [reads the question without problems and puts greater than “>” in between one-fifth and one-sixth]

SW63: [shakes the head in disagreement, says] no

R: SW63 do it your way

SW63: [changes from greater than to less than “<”]

SW64: [draws two rectangles one each representing one-sixth and one-fifth respectively and partitions them into unequal parts and shade the biggest portion in each of the diagrams to justify their answer]



R: How many of you agree with SW64?

SW62: sir we all agree with SW63

R: so all of you agree with SW63

S: Yes sir [chorus]

R: why is it less than, if you agree with SW63?

SW62: sir because one over six is bigger than one over five

R: SW63 do you agree?

SW63: yes sir

R: SW61 do you also agree

SW61: yes sir

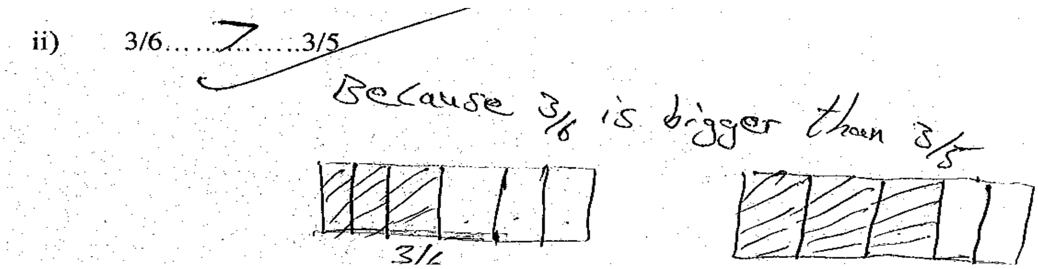
R: alright do the second one [referring to 1(b) ii]

SW64: reads the question without problems

R: do it, I want you to discuss

SW63: [puts greater than in between three-sixths and three-fifths]

SW64: [draws two rectangles, each representing three-sixths and three-fifths respectively, partitions them into unequal parts and shade the required number of portions in each of the diagrams to justify their answer, as shown below.]



R: Do you all agree?

S: Yes sir [chorus]

R: why

SW61: because three over six is bigger than three over five

Question 2 (a)

R: measure and tell the amount of rice in this container, share it among three people and tell how much each will get, feel free to ask for any instrument that you will need to do this task. [Presents the rice in a bag to the children and keeps scale and local unit of measure in a box; both of them visible to children]

S: sir margarine cup [chorus]

R: Provides students with a margarine cup

SW63: [puts three empty containers on the table, using the margarine cup as a unit of measure, and with the help of the other group members, she puts one cup of rice in each container. She goes round the second time and third times. Noting that what was left was not enough for her to put one cup in each of the containers she gives each one of them a half cup; all the rice gets finished.]

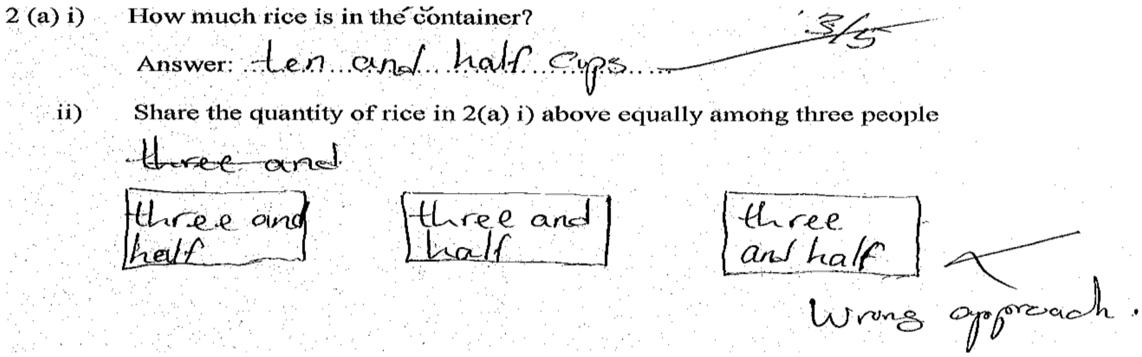
R: how much rice was there in the container?

S: ten and half cups [chorus]

SW63: [writes ten and half in the worksheet]

R: write your solution to the problem in your worksheet

SW63: [draws three rectangles and write three and half in each of them]



2 (a) i) How much rice is in the container?

Answer: ten and half cups 3/5

ii) Share the quantity of rice in 2(a) i) above equally among three people

~~three and~~

three and half

three and half

three and half

Wrong approach.

R: Can I have one of you to explain how you shared? SW61

SW61: We share [sic] among three people…

SW64: We use three things and shared equally

R: how did you share with the three things?

SW62: Sir we gave each of them one rice of “Olonka”

R: are you sure?

SW61: Margarine cup

SW62: Sir Margarine cup, I am sorry, each of them got three and half

R: I want you to show me why each will get three and a half

SW64: Sir see the drawing

R: I can see the drawing; you can explain why to me in Fante

SW64: [explains in the local language] sir we took three things and used the margarine cup to share, we put one margarine cup in each and went round three times, we observed that what was left, if we measure, it would not be possible for us to give each of them one cup, so we put half, half in each of the three things [referring to the containers] and that gave us three and a half.

SW63: Sir we have ten and half cups of rice, we got three things and measured one margarine cup and put it in each of the three things and everybody had three and a half cups.

Question 2(b) Ama bought 5.5kg of rice whilst Esi bought three times the quantity of rice Ama bought. What quantity of rice did Esi buy?

R: read the question [Question 2 (b)] and answer it

SW61: [reads without problems]

SW62: [solves as shown below]

$$\begin{array}{rl} & 5.5\text{kg} \\ \times & 3 \\ \hline & 16.5\text{kg} \\ \hline \end{array}$$

R: SW62 how did you do it

SW62: sir I multiplied three times five and I got fifteen, and I wrote five and the remainder is one and I multiplied three times five and I got fifteen and I added one to get sixteen, that is all.

R: why did you put the points there?

SW62: Sir I think if I do not bring the point there I am wrong that is why I put it there.

R: why did SW62 put the point there?

SW64: [explained in Fnate] because the weight of the things Ama bought was 5.5kg so the point must come in the answer.

Question 3 (a) Papa Kojo gave Abena ¼ of an orange and Ekua 2/4 of an orange. How much orange did Papa Kojo give to Abena and Ekua altogether?

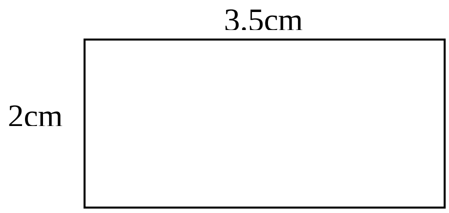
R: read the question and solve it

SW64: [reads the question and presents the solution as a quarter plus two quarters equals three-quarters, as other group members look on as shown below]

$$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$$

S: sir we have finished [chorus]

Question 3 (b) Find the area of the figure below



R: read the question [question 3 (b)] and solve it

SW64: [reads the question]

SW63: [solves leaving the answer as 70]

SW62: put decimal point in between seven and zero

SW63: [finally presents the group's solution as shown below]

$$\begin{array}{r} 3.5cm \\ \times\ 2cm \\ \hline 7.0\ cm \end{array}$$

R: why do you have to put the point in between seven and zero?

SW62: [silent]

SW64: sir because there is a point in three point five so we need to bring point in the answer.

Language of communication among children

[For the out-of-school task children used the local language in communicating among themselves during the activities whilst for the in-school activities children communicated among themselves in both English and the local language.]

Thinking Language

R: What language did you use in thinking as you went through the activities?

SW61: Fante and English

SW62: Fante; I think in Fante and write in English

SW63: sir English and Fante; sometimes I think in Fante, other times in English

SW64: English; sir when I am thinking I think in Fante but when I am writing I write in English

Perceptions about the relationship between out-of-school mathematics and school mathematics

R: what do you think about the mathematics you solved using margarine cups [out-of-school mathematics] and those you solved using the kg, cm etc [in-school mathematics]?

SW64: sir they are different

R: do you all agree that they are different?

S: yes sir [chorus]

R: which of them would you like to study in school?

SW61: the one we used the margarine to measure

SW62: the one we used the margarine to measure

SW63: Kilogram mathematics

SW64: sir the one we worked, kilograms

R: SW62 and SW61 why do you want to study everyday mathematics in school?

SW62: occasionally teacher uses some…. to help us to understand [mathematics]

R: SW63 and SW64 why do you want to study school mathematics

SW63: sir kilogram is sometimes difficult but I can do mathematics involving "Olonka"

SW64: we know "Olonka" already but we do not understand kilogram so we want to learn more of it.

R: which is important for you, school mathematics or out-of-school/ "home" mathematics?

SW64: sir kilogram mathematics [school mathematics] because Kilogram is always in mathematics "Olonka" comes in once a while",

SW61: both are important

R: SW62 and SW63 do you agree that both are important

S: yes [chorus]

R: why are both important?

SW63: when you come across a book which has both of them you can be able to solve them. Kilogram, sometimes, when we see it we cannot do it but "Olonka" I can do it.

R: which people in the society usually use out-of-school/ "home" mathematics?

S: traders use "home" maths [chorus]

SW64: Farmers also use the "home" maths

R: which people in the society usually use school mathematics?

SW63: those who go to school, [and] those who work in office

SW61: doctors

S: teachers and students [chorus]

Children's perceptions about parents' knowledge

R: do you receive support from your parents for your school mathematics homework?

SW61: yes sir

R: you receive support from your parents SW61?

SW61: yes sir, my mother teaches me; my mother is educated, it is only my father who is an illiterate

R: what about SW62

SW62: yes sir; my father teaches me, my mother is an illiterate

R: what about the two of you [SW63 and SW64]?

SW63: sir my mother

SW64: sir no body teaches me; both of them are illiterate

R: How often do your parents teach/ help you with your mathematics homework?

SW61: not often

SW62: often

R: SW62, what language does he use?

SW62: English

R: does he make use of “home” mathematics?

SW62: yes sir

R: what do you think about your parents’ mathematical practices? Do they look like ours [school mathematical practices]?

SW63: no sir

SW64: no sir

SW63: sir she sells so she teaches us how to give change so that we can sell when she is not there, and also how to measure like we did here in the activities [measuring using the local units of measure]

R: Do you think your illiterate parents’ mathematics is good enough? I want to know from you.

SW63: yes sir

SW64: yes sir

SW63: issues concerning money are very important so….

SW64: at times what she [mother] teaches us is similar to what we learn in school

SW62: sir my mother was not educated when I go to her she doesn't teach me anything meaningful, except my dad [who is educated]

R: Do you think your mother's mathematical practices are important?

SW62: yes sir

R: why?

SW62: she sells so that helps her to keep her money well

R: SW61, do you think your father's mathematical practices are good?

SW61: yes sir

R: Why, apart from selling, money etc?

S1: [remain silent]

Perceptions about mathematics

R: I am going show some pictures, look at them carefully and tell me whether those in the picture make use mathematics or not.

R: [shows a picture of a local market woman selling rice]

SW64: she doesn't use mathematics,

S: she uses mathematics [chorus]

R: [shows a picture of a butcher]

S: he uses mathematics

R: [shows a picture of an engineer]

S: he uses mathematics

R: [shows a picture of driver's mate]

S: he uses mathematics

R: [shows a picture of a farmer]

S: he uses mathematics

R: [shows a picture of a primary school teacher teaching]

S: he uses mathematics

R: [shows a picture of a Kente weaver]

S: he doesn't use mathematics

R: [shows a picture of a banker]

S: he uses mathematics

R: [shows a picture of a medical doctor]

S: he uses mathematics

R: [show a picture of a computer programmer]

S: he uses mathematics

Language Use and Preference

R: What language do you usually use at home when you are talking with your parents?

S: Fante [chorus]

R: What language do you usually use at home when you are playing with your friends?

S: Fante [chorus]

R: What language do you usually use in communicating with the teacher and your classmates in the classroom when there is a mathematics lesson?

S: English [chorus]

R: What language do you usually use in communicating with the teacher and your classmates in the classroom when there is no mathematics lesson?

S: we use English with the teacher [chorus]

R: What of your friends?

S: sir Fante [chorus]

R: What language do you usually use in communicating with the teacher and your classmate outside the classroom during break time?

S: English; English with the teacher [chorus]

R: what about your friends?

SW62: sir I use English

SW64: sir I use Fante

SW61: Fante

SW63: Fante

R: What language does your teacher usually use in teaching mathematics?

S: English [chorus]

SW62: sometimes when we are having difficulty understanding he uses Fante

R: What language does your teacher usually use in teaching fractions?

S: English [chorus]

SW62: sir English and Fante

R: What language does your teacher usually use in teaching measurement?

S: English [chorus]

SW62: sir English and Fante

R: What language would you prefer your teacher to use in teaching mathematics? Why?

S: English [chorus]

SW62: maybe when someone comes he will use English to ask us questions

R: SW62, any other reason for English?

SW62: sir no other reason

R: SW63, is there any other reason?

SW63: sir no other reason

SW64: sir, I have another reason when the headteacher comes to talk to us in English we will also be able to use English to answer him.

R: What language would you prefer your teacher to use in teaching fractions? Why?

S: Fante [chorus]

SW62: sir, we want Fante because fractions are very difficult, when he is teaching and we don’t understand we want him to use Fante to explain it to us so that we can understand what he is saying.

R: What language would you prefer your teacher to use in teaching measurement? Why?

S: both English and Fante [chorus]

SW62: sir, because some of the measurement are very easy and others are difficult so we want both languages.

R: so for the easy topics which language do you prefer?

S: sir English [chorus]

R: What about the difficult topic, which language do you want teacher to use

S: sir, Fante [chorus]

R: Were the activities difficult? Did you find it interesting?

SW62: sir we find [sic] it interesting

R: Thank you.

Appendix L - A sample of interviews with teachers

Part I

Name of School: School C

School type: Average

Gender: Female

Level of teaching: Grades six and four

Teaching experience: 11 years

Professional status: Trained

Highest professional qualification: Certificate “A” (Post Secondary)

Venue: School Premises

Date: 20/10/2008

Part II

Language use and preference

R: What language do pupils usually use in the classroom when there is a mathematics lesson?

TC: English language, mostly English language but when it comes to where we have to use role-play then you explain in Fante and then they act, then you get the children to understand the topic better and they apply it but still with the English language.

R: What language do pupils usually use in classroom when there is no lesson?

TC: When there is no lesson they normally use the L1 [Fante]

R: What language do pupils usually use when they are outside the classroom during break time?

TC: Mixture of English language and L1, so both. At times when they see the teacher they try to speak English but when they are on their own with their friends they speak Fante. We stress on the speaking of the English language, both outside and inside the classroom. So when they are outside they think they are at liberty to speak their language, that is why the moment they see the teachers they tend to speak English or they would be prompting themselves to speak it [English].

R: What language do you use in communicating with pupils in class when there is no lesson?

TC: English language

R: What language do you use in communicating with pupils outside classroom during break time?

TC: English language

R: What language do you use in communicating with pupils when you meet them outside the school premises?

TC: It is the mixture; at times you speak the English and sometimes you speak the Ghanaian language. For some, the mood at which you see them they may start greeting you by saying “me pa wo kyaw” [meaning please in English] so with that then either you also unaware speak the Fante to them, but some just see you and say “madam, good morning”, that is English, then you also communicate with them in English.

R: Does that mean the language you use to communicate with pupils outside the school premises depends on the language pupils’ use to greet you?

TC: At times it is sudden, you start with Fante and then you realise and turn to the English

R: What language would you prefer the children to use in classroom during mathematics lesson, and why?

TC: English, because especially with the word problems and problem solving, the sentence and everything is given in English language, so during the mathematics lessons if they understand the English language they can turn the problem to mathematical equations before they are able to solve it.

R: Why so much emphasis on English?

TC: English is the L2 [language of instruction] so I think that is what we have to use.

R: What language do you usually use in teaching mathematics?

TC: It is English language.

R: What language do you usually use in teaching fractions, and why?

TC: English, because it is the medium of instruction and as I said earlier the questions come in English and we have to teach and explain in English.

R: Questions from where?

TC: Questions from textbooks and for examinations.

R: Which examination?

TC: End of term

R: What language do you usually use in teaching measurement, and why?

TC: English language, because the words in the topic are technical, like using the units and the standards, and those things like strides, pace and others, it is the English language that we can use to explain the pace, the strides and the others before we come to the standard units of measures.

R: Would you use the L1 if you get the vocabulary for pace and strides?

TC: No, I will mix the two, but not shifting from the English entirely because English language is the medium of instruction from the policy.

R: What language would you prefer to use in teaching mathematics, and why?

TC: It is English language, because from P4 [grade four] it is the medium of instruction and all questions and lessons come with English language and the textbook is in English so there is no way we can do away with it.

R: What language would you prefer to use in teaching fractions, and why?

TC: English, because as I said, it is the medium of instruction and when you are teaching fractions the key words such as “divide”, “share”, or “take part of” are not so difficult to turn to the local language. The children are familiar with them. I don’t find any problem using the English in teaching fractions.

R: What language would you prefer to use in teaching measurement, and why?

TC: English language, because it is the medium of instruction and then as I said the key words or the technical words translating may be a bit difficult. Like the pace and the strides, to translate, you would explain with a lot of words. But with that word [in English] as you demonstrate they easily get the understanding.

Part III

Use of out-of-school mathematics in classroom context

R: We measure in the local markets using the local units of measures such as empty tins, in what ways do pupils make use of this out-of-school/everyday knowledge in lessons on measurement?

TC: Yes they do, but at the end you see that even though the same container would be used to measure the results would be different. Like we are using the margarine container, you use the margarine container for “gari” another person uses the margarine container for “gari” but after buying from here and here [sic] you see that the results would be different, may be either by pushing the bottom part [of the container] or others, so this results in the standard measurement. When teaching of measurement they are able to mention the local units like the milk tins and the Milo tins and others, but at the end you will see that they would come out with the information that some [traders] hit the bottom part of the container, so when you buy with the same margarine container the results would be different. So they do apply but the concept of the standard measurement comes in at the end.

R: How does their knowledge of out-of-school mathematical practices affect (interfere with/support) their learning in school?

TC: At home if they are sent with one Ghana Cedis [thousand old Cedis] to buy fifty Pesewas [five hundred old Cedis] worth of something they know they are bringing back five hundred but to calculate by writing the one thousand Cedis and taking five hundred, the moving of the one to the zero to make ten and subtract, at times it becomes their problem in class. At home they know that if I take five hundred cedis to buy three hundred of something I would be getting two hundred but to write it down and subtract at times it becomes a bit difficult for them.

R: Why do you think it is a bit difficult for children at school to work and get the answer?

TC: In the house it is some sort of abstract but in the classroom there is the arrangement of the figures and solution to arrive at the final answers. One of the problems is the arrangement [place values], they can write the five hundred and instead of writing three hundred they write three under five and then zero zero under it, they fix the figures anyhow, so at the end getting the correct answer becomes a problem.

R: Sharing is part of pupils' culture; they shared things before they even started formal schooling. In what ways do pupils make use of this out-of-school/everyday mathematical knowledge in lesson on fractions?

TC: Yes they use but the problem arise if they know I am the eldest I should take the bigger part, so when it comes to sharing equally between an elderly person and a younger person then the application doesn't hold. And before you get them to understand better they think if you have 'one out of three' and then 'one out of two' because three is greater than two they may choose one out of three to be bigger and in that sense you may have to explain with the teaching material and then apply it before they get the understanding.

R: How do you handle the situation of children sharing, knowing that one is older than the other?

TC: you make them understand that the sharing at home may be different, unless they come to ratio, but with the equal proportion unless you tell them that everybody gets the same quantity, so with the use of the fractional chart, strips of papers and cutting of papers they get to understand.

R: How does that affect (interfere) their learning?

TC: Yes, it interferes their learning, when comparing fractions that is where the problem comes but with the teaching materials used, by the end of the lesson they overcome that problem.

R: In what ways do you make use of out-of-school/everyday mathematics practices in pupils' local culture in your teaching?

TC: By role-play, for example if I am teaching word problems involving addition or subtraction, then they role-play, where one acts as a father or a mother asking the son to buy certain things and give a certain amount. Then at the end of the purchases what amount is brought to the house, and including the items, so they are sent to buy things and then they are given a certain amount of money, the amount they bring home, and it leads to subtraction.

R: Please can you tell me about the language policy?

TC: Yes, from P1 to three, that is the lower primary and now KG inclusive, the English language should be taught as a subject whiles the L1 is used as the medium of instruction. Then from P4 onwards the English language is used as a medium of instruction as well as a subject, [and] then the L1 becomes a subject.

R: How does the language policy affect the use of out-of-school cultural notions in your mathematics teaching in school?

TC: The moment the children leave the house to school the L2 should be used because changing over from Ghanaian language to English language as the medium of instruction from P4 is causing a lot of downfalls in education system, especially during examinations. They come to the school from KG or Class one, they come to school, they are speaking the Ghanaian language, they go home they are speaking the Ghanaian language, so from P4 as the change over takes place then the problem still remains, so it affects the teaching from P4. If they had started with the English language from P1, then from P4 they would be fluent in the language and then as it is used as a medium of instruction it would not be a problem or any difficulty.

R: I would like to know more about how the language policy affects the use of out-of-school cultural notion.

TC: When they come to the lower primary the medium of instruction is the local language as they find in their home. Now from P4 onwards they changeover, so I am saying that the problem arises when they changeover from P4 and keeping the home one from P1 to P3. So keeping what they have at home, “ekor”[one in English language] “ebien”[two in English], and when they come to school “ekor” “ebien”, it doesn’t make any difference, but when the changeover [from local language to English as a medium of instruction] comes, that is where the problem arises.

Part IV

Transition experiences

R: You did tell me that in fractions, they bring in the home idea and that disturbs the whole lesson, is that right? So how do you usually handle such situations?

TC: That is where the explanation of equity comes in, so we don't consider you as the eldest or whatever, but equity, we want to share it equally, especially taking the class, we are all in this class, say four or six, so we share it equally. That is how I solve the problem.

R: I want to get it clear from you, do you mean you ignore what they have brought with them and go on to explain the school situation?

TC: Yes

R: Could you say a bit more?

TC: The school situation is used to explain for them to keep the home one aside especially during fractions lessons

R: Why do you handle them the way you do, why do you use the school situation so that they put the home one aside?

TC: Because that is what the syllabus that has been provided for us to follow says. Though the school has the syllabus to be followed they [children] know the home one, so if they bring it up, you teach them what the syllabus says or what has been prepared to be followed.

R: Do you collaborate with parents to help pupils' mathematics learning?

TC: Yes

R: When does it become necessary for you to do it?

TC: There are some of the children who are very weak in the subject so if such a pupil is observed then the parents would be invited to talk to so that they would see to the child at home, to do any assignment or to learn at home.

R: How do you do it?

TC: By inviting the parents to come to the school, and then suggesting solution to the parents. Then also particular attention is given to the child in the class.

Appendix M - Samples of interviews with headteachers

M01: A sample of interviews with headteachers stage I

Part 1

Name of School: School L

School type: Below Average Achieving School

Gender: Female

Number of years employed as a headteacher: 10 years

Teaching experience: 36 years

Professional status: Trained

Highest professional qualification: Certificate "A" (Post Secondary)

Date: 3/10/2008

Venue: School's Premises

Part II

R: Tell me about your school's language policy and language use generally?

HL: Generally, we use the English language when we are teaching. We use the English language at all levels, but when the children are finding difficulty in understanding we use the local language. Normally, in the lower primary we are allowed to use the local language, for the simple reason that sometimes the children find it difficult understanding the English language. We feel by all means they have to understand, so we have to come down to their level by using the Ghanaian language, just to make them know what we are trying to tell them, so at the lower primary level we use a mixture of the English and Ghanaian language.

R: Which of the two is more, English or Ghanaian language?

HL: English is more, about 60%. For example, when we are teaching them English they are not supposed to use Fante at all. When teaching English we normally concentrate on the English language only. It is on few occasions that we use the local language, for example, when there is a word that the child does not understand we use the local language to explain. When it comes to other subjects we normally bring in the Fante. In fact, the community itself, I don't even know the word to use; they are not all that enlightened, even when you encourage them to speak the English language at school you do not get the parents' support. If we do it here in the school and parents support them in the house then it becomes more effective, but most of the times when the children are not getting the understanding we feel by all means they have to understand what we are saying, then we come down to their level.

R: Tell me about parents' participation in the school activities.

HL: We have the PTA, they have been participating, when we invite them to come to the school they come. They have given us specific days that most of them would be available to come for meetings, so when we invite them for meetings they come. When there is any project in the school and we need their support they come to the school to help voluntarily. They don't even take anything from us, they also come to the school. We have about four of them who almost every week comes to the school to see how the teachers are doing. They even check on attendance of teachers. I remember one came to my office last week and a teacher came in late. When the teacher left he questioned me, why the teacher had come to school so late, so all these things show how concerned they are about the school. Also, they have supported us by putting up a building for us to cater for primary six pupils, so they have been supporting us. If children need books they buy them for the children, in fact most of the times they have been supporting us.

R: Do you usually invite parents to the class?

HL: Just a handful of them, they come, we don't even invite them before they come. Just this morning, before you came in, a parent was here to check whether the child has been coming to the school because this parent had been told that the child was playing truant, so he came to check whether the child had been coming to the school. They normally come when we have open days, and then they come to check on the work that their children have been able to do.

R: Is parents' participation in the Open days encouraging?

HL: Yes, they come, the chief of the town himself and other elders they all come.

R: Are the parents used as resource persons?

HL: Yes we use them. There was this Assemblyman [community leader] he works at the Municipal Council, we ask him to come and give a talk on their personal hygiene.

R: As a headteacher you have the sole responsibility of endorsing what the teacher must teach in the classroom in Ghanaian schools. Tell me about use/non use of out-of-school cultural notion by the teachers in mathematics in your school.

HL: We used to but now we are trying to discourage that. At first, the children use to count their fingers one, two, three, four, five, six, but this time we don't want to encourage that. Now, for the class one instead of children counting their fingers they use the chalkboard. Teachers write them on the chalkboard in groups for the children to identify the number.

R: Madam why have you discouraged it? I want to learn

HL: Well we don't want to encourage it in the sense that sometimes even when the children go to the upper primary because they are used to that [out-of-school cultural notions in mathematics] at the lower primary and Kindergarten they feel they should continue from that level too. For example, three days ago a small girl in class three was writing a sentence and then she did something that was very interesting, because they have been taught how to space with the fingers, at that stage [grade 3] she was still using fingers in spacing the sentence that she was writing and I felt she was too matured to go down to that level because it is in the Kindergarten that they use that sort of thing. At a certain level we feel we have to discourage them just to make them pay more attention on the board.

R: What do you think about these out-of-school cultural notions in mathematics generally?

HL: I feel in the home that is what prepares the children for school. It is a sort of informal education; it prepares them before they come to the formal sector.

R: Are you suggesting that out-of-school cultural notions in mathematics are good for home.

HL: Yes, it is good for home.

R: What about the school?

HL: I feel for home it is better.

R: Do you think it may be good for upper primary or lower primary or you still think it is better for home?

HL: In the upper primary no

R: What about the lower primary?

HL: The lower primary … well I feel the Kindergarten is better because this time round all the preparations are made at the kindergarten. In our time we were able to read when we were in class one but this time you will be surprise to know that even some Kindergarten two pupils can read. All these preparations go on at the Kindergarten before they go to class one. Normally you don't even see the class one pupils using such things.

R: What do you think about out-of-school mathematics in the Ghanaian society such as "Pole" as a unit of measure of land, "Olonka" as a unit of measure of grains, "pon" as a system of counting etc.

HL: Well when I think of out-of-school mathematics, taking our mothers who have not been to school before in fact this is what is helping them in the market, because most of them are illiterates, they cannot read, they cannot write, so without the out-of-school mathematics it means they can't even sell. So we see that out-of-school mathematics is good for the illiterates because it helps them in their trading and in their day-to-day activities.

R: What about the literate?

HL: For the literate we can read, we can write, for example when a woman is baking cake she needs to measure these things; sugar, margarine, [and] what not, on the label. If it is one kilo you see that this is one kilo and you are using it, and there is no mistake, but for the illiterate sometimes they use the handy measures. They will say that this is one pound so I will use it only to find out that the result would not be as you want it to be, so for the literate we can read so we know what we are supposed to use at a given time.

R: Thank you very much, if you have any general comments you may want to pass.

HL: Ooo … I have also enjoyed our conversation; the questionnaires gave us so many things to learn. I personally have learnt a lot, and some of the teachers also said the same thing.

R: I am happy to learn this from you madam, I am so grateful, thank you.

M02: A sample of interviews with headteachers stage II

Part I

Name of School: School C

School type: Average school

Gender: Male

Experience as a headteacher: 2 years

Teaching experience: 10 Years

Professional status: Trained

Highest professional qualification: B Ed

Date: 20/10/2008

Venue: School Premises

Part II

Language use and preference

R: What language do pupils usually use in the classroom when there is a mathematics lesson?

HC**:** Basically we use our own language which is Ghanaian language to explain some concepts kids don't understand at all levels in primary school. At the lower primary we use the Ghanaian language in teaching mathematics and at the upper primary, that is, primary 4, 5, 6, we use English language.

R: What language do pupils usually use in the classroom when there is no lesson?

HC: Basically they use Fante, I think when they use their own language it enhances understanding between the pupils.

R: What language do pupils usually use when they are outside classroom during break time?

HC: Ghanaian language; they use the same language.

R: What language do teachers use in teaching mathematics?

HC: It is both; English and Ghanaian language. In mathematics I think there are some concepts where they need to explain for the kids to really understand what they are teaching. Basically for the lower primary they use Ghanaian language because we think with the Ghanaian language they would understand it better but in the upper primary they use both the English and the Ghanaian language. The Ghanaian language is used in the upper primary for explanation. When they want to explain something then they use Ghanaian language in the upper primary.

R: What language would you prefer teachers to use in teaching mathematics and Why?

HC: To use Ghanaian language at the lower primary level because at that level they would understand it better. That is why we use Ghanaian language at the lower primary when we teach mathematics but in the upper primary they are a little bit grown so I prefer the use of both Ghanaian language and English language. Ghanaian language should be used there for the explanation of certain concepts they think the kids don't understand.

R: Please can you tell me about the language policy?

HC: The language policy states that for the lower primary they use their mother tongue and upper primary L2, which is the English language, that is, [in] upper primary English only.

R: How does that affect teachers' inclusion of out-of-school cultural notions in their mathematics teaching in school?

HC**:** One thing is that since the kids from class one to class three they are conversant with the Ghanaian language, when they are in their house it is the Ghanaian language that they normally use, so when teachers are teaching and they use the same language children are conversant with, it enhances their understanding. So with that, the language policy rather enhance understanding, but in the case of upper primary, though the language policy states that they should use English throughout, it hinders understanding to some extent, because not all the kids are conversant with the use of the L2, which is the English language. That is why there we combine both the English and the Fante so that it would enhance understanding among the school pupils.

R: What about its effect on the use of out-school-cultural notions?

HC: It affects it to some extent, because not all the kids in the upper primary are conversant with the use of the English language. That is why we on the ground are saying no if that is the case we would use English and the Ghanaian language

Part III

Use of out-of-school mathematics in classroom context

R: Tell me a bit more about your thinking about the use of out-of-school cultural notions in mathematics.

HC**:** In addition, what I can also say is that a topic like measurement in the house the kids are aware because normally they hear their parents using “Olonka” and margarine “kor” and that kind of thing, it is measurement, so with the kids having this overview and the understanding some of these terms that are used in our various houses when they come to school it facilitate learning because they are already aware about certain things like “Olonka” and those things, so it is just a matter of using English to explain that thing and I think that one has been helping a lot.

R: How do your teachers usually make use of out-of-school cultural notions in mathematics in their mathematics lessons?

HC: Sometimes we ask them what do they know about measurement and you would be surprised that the kids would be giving you some information that you normally want. So basically it is through questions, sometimes too we give them assignments they should go and find it out, sometimes too we group them. Like for instance in measurement, a group of children are asked to find out what their parents use in measuring things, is it “Olonka” or what? Another group margarine “chence” another group “rubber” and so on, so that is how we group them for them to know the capacity of each container used in their various homes. Assignment requiring children to find things that can be measured are also given to children

R: Tell me a bit more about your thinking about the use of out-of-school cultural notions in mathematics at the lower primary, upper primary and Junior High School (JHS) levels

HC: As I said before, in the community they normally sell so this kind of addition, fraction and measurement they are conversant with it. The kids, most of them sell after school so they know this kind of measurement, the addition they know, subtraction and what have you. So having this in mind when they come to school they are already aware because they sell, they are aware of addition, subtraction and multiplication; the four main operations. It is relevant throughout even from Kg to JHS three [grade 9]. It is very very relevant because as I said before they have heard of “Fa ka ho” that is addition, “tsiw fir mu” that is subtraction they are aware of these so it is like when they come it is used as their RPK which enhances introduction of the lesson and it makes the lesson very lively and understanding.

R: Tell me a bit more about your thinking about out-of-school mathematics in the Ghanaian society such as “pole” as a units of measure of land, “Olonka” as a unit of measure of grains, “pon” as a system of counting etc

HC: It is very important and relevant because if you are teaching in community where the kids more often than not encounter with this “Olonka”, additions, subtractions and what have you, it is very relevant because it makes the teaching very easy and understanding.

Part IV

Transition experiences

R : What are some of the cultural differences that pupils bring forward during mathematics lessons?

HC: The differences is unit; they are aware about the local units of measurement but when it come to for instance cm, kg, litres, grams and what have you, they just know measurement but the unit to assign, that is, is it in cm, it in metres? They don't know; all that they know is measurement.

R: How do teachers usually handle these problems?

HC: The teachers take them through the units of measurement, that is, units assigned. We normally take them through cm, metres, mm, kg and what have you. We take them through those terms used before we introduce the actual measurement.

R: Why do you think the teachers approach it that way?

HC**:** The policy (syllabus) states that they should measure by assigning units to it. It is in the objectives; it is stated clearly/emphatically that kids should know the common SI units. That is why teachers normally take them through, so it is the policy that teachers are to go through with the kids.

R: In what ways does the school encourage teachers to collaborate with parents to help pupils' mathematics learning?

HC**:** Sometimes we organise meetings between the parents of the kids and the teachers.

R: Why does the school see the need for teachers and parents collaboration in pupils' mathematics learning?

HC: When the teacher knows the background of the child it is used as the basis for teaching the pupil. At times parents' background is also used as the basis for collaboration, that is, the environment, for instance if we know that the parents of the child are illiterates automatically there is a link between the child and the parents and thereby using that as a basis to teach mathematics.

R: When does it become necessary for you to organise the meeting?

HC: It is when we realise that the concept stated in the mathematics syllabus is different from what the children give us; so it is then that we say that we should rely on the parents.

Appendix N - A glass one-sixth full of water and a glass one-fifth full of water

Appendix O - A glass three-fifths full of water and a glass half full of water

Appendix P - Background of students' participants

Table P01: Background of student participants in School C

Level	Student	Gender	Age (years)	Level of achievement
Grade six	SC61	F	12	HA
	SC62	F	12	LA
	SC63	M	12	HA
	SC64	M	12	LA
Grade four	SC41	F	13	HA
	SC42	F	15	HA
	SC43	M	10	LA
	SC44	F	10	LA

Note: F-female, M-male, HA-Higher achiever, LA-Lower achiever (relative to rest of the class)

Table P02: Background of student participants in School L

Level	Student	Gender	Age (years)	Level of achievement
Grade six	SL61	F	14	LA
	SL62	F	14	LA
	SL63	M	11	HA
	SL64	M	11	HA
Grade four	SL41	F	14	HA
	SL42	M	10	LA
	SL43	M	11	LA
	SL44	M	13	HA

Table P03: Background of student participants in School X

Level	Student	Gender	Age (years)	Level of achievement
Grade six	SX61	F	13	LA
	SX62	F	14	HA
	SX63	M	14	LA
	SX64	M	12	HA
Grade four	SX41	F	9	HA
	SX42	M	12	HA
	SX43	M	9	LA
	SX44	M	10	LA

Table P04. Background of student participants in School W

Level	Student	Gender	Age (years)	Level of achievement
Grade six	SW61	M	13	LA
	SW62	M	15	HA
	SW63	F	19	LA
	SW64	M	16	HA
Grade four	SW41	M	14	LA
	SW42	F	9	HA
	SW43	M	10	HA
	SW44	F	9	LA