Everyday Mathematics in Ethiopia: The Case of the Khimra People

Hilluf Reddu Tegegne

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This is to certify that the thesis prepared by Hilluf Reddu, entitled: ***Everyday Mathematics in Ethiopia: The Case of the Khimra People*** and submitted in fulfillment of the requirements for the degree of Doctor of Philosophy (Mathematics Education) complies with the regulations of the University and meets the accepted standards with respect to originality and quality

Signed by the Examining Committee:

External Examiner: Prof. David Mogari________ Signature: __ Date: ____

Internal Examiner: _Ambissa Kenea (PhD. Asso. Prof.)_ Signature: __ Date: ___
Principal Adviser: Asmamaw Yimer (PhD, Asso. Prof.) Signature: ____Date:__

Co-adviser: Solomon Areaya (PhD, Asso. Prof.)__ Signature: ____ Date; ___

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ABSTRACT

Everyday Mathematics in Ethiopia: The Case of the Khimra People

Hilluf Reddu
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The issue of connecting school mathematics contents and instruction to the learners' socio-cultural and real life context is increasingly attracting the attention of educational practitioners including teachers and students themselves. The overall aim of the current study was to investigate the everyday mathematical practice and the issue of connecting in-and out-of-school mathematical practices. Guided by the desire of adding empirical knowledge, the present study examined this issue in one of Ethiopia's ethnic groups, the Khimra people. The study was conducted in eight workplaces, two games, and two schools selected purposively. Twenty five informants were purposively selected from these workplaces, games, and schools. The study used a qualitative multiple (embedded) case study design to address the problem of connecting workplace and school mathematical practices that the current literature in Ethiopia does not adequately cover. Data obtained from interviews, field notes, classroom and workplace observations, and documents were analyzed and discussed using Saxe's (1991) analytical framework. The results demonstrated that people engaged in workplaces outside school use mathematical ideas, concepts and procedures in their real life activities. Interviews with and observations of participants in workplaces showed that the nature and activity structure of a given work leads to a particular mathematical practice and this mathematical activity helps the successful accomplishment of the work. Moreover, the findings showed that in- and out-of-school mathematical practices can interplay to enhance the process and means of achieving the goals of one another. However, this potential interplay is not researched and recognized by educational practitioners such as teachers. Therefore, it is possible to claim that learning and understanding of mathematical concepts by students can be enhanced by the positive interaction between the in- and out-of-school mathematical practices. The implication of these findings is that understanding the out-of-school mathematical practices and their roles in improving school mathematics instruction is useful to inform larger policy goals about the importance of contextualizing mathematics curriculum and instruction. The challenges mentioned by teacher participants also imply that teacher training colleges need to give attention to this issue to inform their trainees and future teachers about the importance of contextualizing mathematics instruction.

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Thank you all! Without you, this would not be possible.

Dedication

Dedication of this paper is to my mother Sesen Alemu Weldemariam who passed away on June 2, 2013 while I was in the field for data collection for this study.

May God Place her soul in haven!

I love you and I will miss you and your love, mom. RIP.

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List of Abrevations

ADLI	Agricultural-Development-Led-Industrialization
ALP	Adult Literacy Program
ANRSEB	Amhara National Regional State Education Bureau
CEE	Civics and Ethical Education
CI	Curriculum Improvement
CSA	Central Statistical Agency
EOTC	Ethiopian Orthodox Tewahido Church
EPRDF	Ethiopian People's Revolutionary Democratic Front
ERGESE	Evaluative Research on the General Education System of Ethiopia
ESDP	Education Sector Development Program
ESR	Education Sector Review
FDRE	Federal Democratic Republic of Ethiopia-
GEQIP	General Education Quality Improvement Package
GTP	Growth and Transformation Plan
ICT	Information Communications Technology
LM	Leadership and Management
MoFED	Ministry of Finance and Economic Development
MoE	Ministry of Education
NCTM	National Council of Teachers of Mathematics
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
SCTE	Seqota College of Teacher Education
SIP	School Improvement Program
SMET	Science, Mathematics, Engineering, and Technology education
TDP	Teacher Development Program
TGE	Transitional Government of Ethiopia
TVET	Technical Vocational Education and Training
UNESCO	United Nations Educational, Scientific, and Cultural Organization
VAT	Value Added Tax
ZPD	Zone of Proximal Development

CHAPTER ONE

INTRODUCTION

Education is concerned with preparation for life (Winch, 2002). It is necessary for education system of a country to work towards this target. But educational policies and practices may vary with the varying ideologies of governments of different countries. This shows that it is necessary to have common aims of education that emphasize on the preparation of citizens for future life. So, a report prepared by a commission of the UNESCO to the international conference of UNESCO in 1996 identified four main aims of education viz. learning to know, learning to do, learning to be, and learning to live together (Delors, J. et al., 1996). The first aim of education is related to acquisition of knowledge. The second aim is concerned with practical or vocational or labor related skills. The third aim is about individual skills that include self confidence, moral and identity building related personalities. The fourth goal deals about social skills such as cooperation and interaction skills. The last three of these educational aims prepare the child or the learner for future life including work and good citizenship.

This four-pillar model of education is, however, criticized for focusing on the future life of the learner in the expense of effective participation in the present social practices and processes (Tawil & Cougoureux, 2013). But still advocates of this model tried to address this critic by going into deep explanation. For example, according to Scatolini, Maele and Bartholome (2010), the pillar 'learning to live together' includes horizontally the current local, regional and global variables of social participation and vertically the past and future social participations. This shows that the present social participation and personality of the learner is not ignored in the four pillars. Another critic is that the four pillars of education are dominated by humanist perspective that gives less emphasis on the economic aspects of education (Tawil & Cougoureux, 2013). But a question posed to this critic is that: isn't the economic aspect of education embedded within the pillar of 'learning to do' that prepares the child for future work? So, the problem (if it exists) of addressing economic and market aspect of education does not lie on the pillars of education but in the implementation of countries as well as at the school level (Shrimal and Sharma, 2012).

Thus, most school curricula of countries have, until recently, focused on the first aim that deals with knowledge acquisition and information provision (Amare, 2009; Shrimal and Sharma, 2012; Tawil & Cougoureux, 2013; Winch, 2002). That means the main goals related to preparation for work and developing the personal and social dimensions of the child are less emphasized. These aims of education can only be addressed if the school curricula are devoted to make their contents and methods of delivery relevant to the present and local practices of the child as well as the future working situations, economy and society that the child is in (Winch, 2002). This requires making education relevant to the local peoples' culture, practices, and indigenous knowledge.

According to Ernest (1991), since mathematics is one of the subjects of educational institutions, its aims should go in line with the aims of the broader education. So, the three important aims of education are also missing in mathematics education (Amare, 2009; Sawyer. 2008). Moreover, mathematical knowledge has been traditionally considered as absolute and infallible (Ernest, 1991). As a result, the curriculum and instruction of mathematics has been more of authoritative where students are considered inexperienced and passive recipients of mathematical knowledge presented by books and teachers.

This absolutist view of mathematics and its traditional mathematics teaching and learning has been challenged since the introduction of multicultural educational perspectives in general and ethnomathematics in particular to mathematics (Bishop, 1997, 1998; D'Ambrosio, 1985; Gerdes, 1998). This challenge has emerged because educators and researchers in the field of mathematics education have recognized that mathematical knowledge is a social and cultural phenomenon. And hence they argue that mathematics should be learnt and taught in relation to socio-cultural contexts with real tasks and activities that engage the learners (Ascher, 2002; Bishop, 2008).

1.1. Background to the Study

Ethiopia is a country with great geographic, ethnic and cultural diversity with total area of 1.1 million square kilometers holding a total population that exceeds 80 million peoples (MoE, 2012, 2013). The federal government of Ethiopia has been implementing different and consecutive development strategies such as Plan for Accelerated and Sustained Development to End Poverty (PASDEP) with the main strategic aim being eradicating poverty (MoFED, 2010, 2014). As a strategy to implement the plans of development, the country has launched its five year Growth and Transformation Plan (GTP) in 2010 in order to reduce poverty from the nation (MoFED, 2010). Education sector is one of the issues emphasized in the GTP.

The education sector of Ethiopia has passed different policies and practices in the history of the country. The primitive system of education in Ethiopia is the traditional educational system. The phrase 'traditional education' is used here to refer to the education that takes place not under the control and budgetary support of the government. In her article about traditional education, Eleni (1992) stated that learning can undergo "everywhere- in the home, the fields, the gathering places, the marketplace, the forest, caves, or shrines, by the lake or riverside, at weddings and festivities and funerals" (p. 8). At home, in the field or the gathering places, people may engage on work related activities or play games (Nkopodi and Mosimege, 2009; Solomon, 2009). This shows that the traditional educational system takes place anywhere including in the play or game. So, it is a lifelong education. The aims of this traditional lifelong education are to lead the child to fullness of life and personhood (Bridges, Amare and Setargew, 2004; Eleni, 1992).

According to Eleni (1992), traditional education of Ethiopia can be classified into two branches. The first branch is traditional education occurring outside religious institutions which may be at home or out-of-home (workplaces) and the second type is religious education.

At home the child learns different subjects such as language and mathematical skills from his/her mother, elder brother or sister, friends at the playground, and from his/her practices until the age of five or six years (Eleni, 1992). In language learning, the child listens to some words (including mathematical counting) when the family has a conversation and then tries to know their meaning and try to pronounce them as correct as he/she can. This is a kind of apprenticeship type of teaching and learning where the learner observes the actions of the teacher and then tries to do that activity individually under the guide and help of the teacher (Lave, 1988). The out-of-home traditional education takes place at different workplaces such as in the farmland, in fetching of firewood or water, looking after domestic animals, in social events such as wedding and holiday ceremonies.

The teaching method of *Moya (*skill*)* and other subjects such as language and mathematics at home or out-side home involves demonstration, direct observation, explanation, and learning by doing (where the child learns from the practices of fetching some objects to his/her mother or other elder and counting his/her cattle), and the teaching materials used are made or grown locally (Eleni, 1992). Therefore, some of the strengths of Ethiopia's traditional education, that the modern education system has to learn from it, are: that the entire family and community participates in it; the teachers are part of the child's everyday life; and every member of the family has the responsibility to care and teach his/her younger which is why there is no failure and dropout in this education. Moreover, its contents and problems arise from the society's needs, traditions and history. It also has vital role in transmitting values of that society and the language of teaching is understood by the children (Eleni, 1992).

The second category of traditional education is that of religious education. Some writers argue that both the Ethiopian Orthodox Tewahido Church (EOTC) and the Islamic religions had put their finger prints on the education of Ethiopia. However, many scholars and researchers agree that the most influential religious education in Ethiopia which drove the aristocracy and government was the EOTC education for long period of time (Bridges et al., 2004; Eleni, 1992; Mulugeta, 1959; Pankhurst, 1972; Paulos, 1976, 2008; Tekeste, 1996, 2006). The religious church education has introduced Ethiopian youth to the Ge'ez language and Saban alphabets including numerals (Tilahun, 1996).

According to Paulos (1976), the church education was more structured than the outside church traditional education and has two major levels. In the first and elementary level schools, children learn to read and write the Ge'ez language's more than 231 characters including reading, rote learning, writing and elementary numerical studies (Eleni, 1992; Paulos, 1976). The second level of traditional church education is the higher level education. In this level, fundamental church music, mass music or liturgy, religious dance, poetry and grammar of Ge'ez language, and mathematical study dealing with computation of church calendar and that mathematics is called Merha-ewuran to mean a guide for someone who is unable to see (Eleni, 1992). Mathematics was used and practiced in the everyday life activities of the people even when there was no formal and Western type of education in the country. The mathematical knowledge of the priests of the church, for example, was helping the society to accomplish everyday work activities. Olivastro (1993: 18) describes this as:

> The story is told of a colonel who wished to purchase seven bulls, each costing 22 Maria Theresa dollars. The owner of the stock called the local priest, who performed the necessary multiplication by digging a series of holes (called houses) arranged in two parallel columns. At the top of one column, he placed 7 pebbles (the number of bulls to be purchased) and at the top of the second column, he placed 22 pebbles (the cost of each bull). The colonel reports:
>
> It was explained to me that the first column is used for multiplying by two: that is, twice the number of pebbles in the first house are placed in the second, then twice the number in the third, and so on. The second column is for dividing by 2: half the number of pebbles in the first house are placed in the second, and so on down until there is one pebble in the last house. Fractions are discounted. The division column is then examined for odd or even number of pebbles in the cups. All even houses are considered to be evil ones, all odd houses good. Whenever an evil house is discovered, the pebbles are thrown out (from both columns) and not counted. All pebbles left in the remaining cups of the multiplication column are then counted, and the total of them is the answer.

First column (for multiplication)	Second column (for division)
~~7~~	~~22~~
14	11
28	5
~~56~~	~~2~~
112	1
<u>154</u>	

Multiplication was practiced by doubling, canceling the numbers that correspond to the evil (even) numbers in the column of division by 2, and then by adding the remaining numbers in the list. This mathematics contributed to the development of binary base number system used in modern computers (Olivastro, 1993).

The teachers of these church schools located in churches and monasteries are priests and debteras. Some of the drawbacks of the church education criticized by intellectuals were that the teaching methods were mostly rote memorization and teacher centered (Eleni, 1992). The modern education seems influenced by this trend since the instructional practices in modern schools are more of authoritative and teacher centered. The church was also blamed for its inattention of scientific and innovative education.

Although the EOTC stood against scientific knowledge in fear of cultural remix, European missionaries tried to introduce modern education even before 1900 (Tilahun, 1996; Wuhibegezer, 2013). It was Emperor Menelik II of 1889-1913 who introduced the first secular and modern education in Ethiopia by opening the first secular elementary school called 'Menelik II School' in 1908 in Addis Ababa, the capital of the country (Hagos, 1966; Roschanski, 2007; Solomon, 2008). According to Atkin and Black (2003), a secular education is government financed and controlled education system that opens its doors not to people of a specific religion or to some part of the population but to all citizens of a country as an instrument for forging a new sense of nationhood. So, Emperor Menelik II introduced a secular education since he was jealous of the European powers-in a sense that he was keen for equating his country's development and modernization to these powers-recognizing that these powers are fruits of education (Hagos, 1966; Raschanski, 2007).

The period 1908-1935 can, therefore, be considered as the period when modern education laid its base. At the end of this period, there were 20 public schools serving about 8000 students throughout the country (Roschanski, 2007). Moreover, there were about 125 educated Ethiopians trained abroad and serving their nation during this period (Mulugeta, 1960). Among the subjects studied in the schools were:

mathematics, physics, chemistry, engineering and so on (Alemayehu & Lasser, 2012; Solomon, 2008). However, the education of this period is criticized for the language of instruction was foreign language (English or French) and the teachers and textbooks were completely imported (Hagos, 1966). Moreover, the contents and teaching methods as well as their organization reflected the cultures and values of Western countries such as France (Alemayehu & Lasser, 2012; Solomon, 2008).

Although it was in its infancy stage, the modern education of Ethiopia encountered obstacle by the Italian invasion and war that lasted five years period of 1936-1941 (Alemayehu & Lasser, 2012; Fassil, 1990; Pankhurst, 1972; Solomon, 2008). Hence, this period can be called dark period for the development of Ethiopian modern Education because the country was in war, the few educated Ethiopians were killed, and the few schools opened before the war were closed (Alemayehu & Lasser, 2012; Fassil, 1990; Pankhurst, 1972).

After the Ethiopian patriots have completely ousted the fascist Italia in 1941 from the country, Emperor Haile Sellassie resumed power and began to reconstruct every sector (including education). The aims of education during this period, among others, were: to provide universal access to education as rapidly as possible and in all parts of the country; to prepare the nation's youth to live in a globalized world/community; to bridge the gap between school and society; and to foster a rational and scientific outlook on life (Alemayehu and Lasser, 2012). However, still the education system alienated the Ethiopian youth from their original cultures since the curriculum and textbooks reflected the traditions of Britain during the first decade (1942-1951) and United States of America during the last two decades (1953-1973) of this regime (Alemayehu and Lasser, 2012; Eleni, 1992; Fassil, 1990; Mulugeta, 1960; Solomon, 2008).

Other challenges of the education system during this regime include: inadequate and unstable teaching force and decontextualized curriculum and instruction; high dropout and attrition rates; disparity in school expansion and enrolment between rural and urban areas as well as among ethnic groups; and high student-teacher and student-section ratios (Alemayehu and Lasser, 2012; Fassil, 1990). To overcome these challenges, the Ministry of Education was taking some important measures. One such action, among others, is the Third Five-Year Plan (1968-1973) which was commenced with goals to provide educational opportunity to all Ethiopians including the rural areas and to provide an educational system that runs scientific outlooks in harmony with the Ethiopia's cultural traditions (Alemayehu and Lasser, 2012; Fassil, 1990). Finally, the Education Sector Review (ESR) was launched in 1971 in order to investigate the failures of previous activities and to identify priority issues in education and training system of the future (Fassil, 1990) though its findings and recommendations were not acted upon due to opposition from the peoples in general and students and educated peoples in particular as well as change in government and ideology as a result of such oppositions.

The next system in the history of Ethiopia was the Derg regime. Education was one of the sectors that the Derg quickly wanted to emphasize in order to soothe the socialist/communist ideology in Ethiopia. The Derg's educational aims read as: to create improved production, scientific research and political consciousness (Alemayehu & Lasser, 2012). Mathematics, natural science, language, social science, philosophy of Marxism-Leninism, crafts, sports, and music were among the subjects taught (Solomon, 2008). Instructional language continued to be Amharic in primary (grades 1-8) during this Military Derg's educational system (Alemayehu & Lasser, 2012; Solomon, 2008).

The problems identified during this period, according the findings of the project Evaluative Research on the General Education System of Ethiopia (ERGESE), were related to the poor style of presentation of contents of subjects; medium of instruction, poor integration and coordination in the structure of education (primary, junior and secondary education); mismatch between expansion of education and the economic resources and capabilities of the government; as well as poor textbooks, high pupil to teacher ratio, and poor competence of teachers (Alemayehu & Lasser, 2012; Solomon, 2008).

After ruling Ethiopia for 17 years, the Military government was overthrown by a party of guerrilla fighters called Ethiopian People's Revolutionary Democratic Front (EPRDF) in May 1991. Although it took power in 1991, the Transitional Government led by EPRDF introduced the current education and training policy in 1994. The first two years (1992 and 1993) were preparatory years to produce federal constitution and launching of different proclamations for different sectors including the education sector (Tekeste, 2006). Two of the main aims of this new education system are bringing up citizens who show positive attitude towards the development and dissemination of science and technology in society and cultivating the cognitive, creative, productive, and appreciative potentials of citizens by appropriately relating education to environment and social needs (TGE, 1994; *p. 7-8*).

The federal government of Ethiopia introduced a new education and training policy needing to change the existing political ideology with a new one. The major changes focused on the curriculum, instructional medium, the structure of the education system, and decentralization of educational administration to regional states and city administrative councils (Bulder, 2007). With regard to the instructional language, for example, Amharic and English are given as national and foreign language subjects respectively in all grades and the mother tongue language became language of instruction in primary schools (grades 1-6) with some variations in different regions (Solomon, 2008; Tekeste, 2006).

Nevertheless, the challenges and failures of previous educational systems of past regimes are raised and becoming centers of criticism still in this new education policy. For example, the systems from the period of Menelik II through that of Haileselasie and Derg were criticized for the poor quality of education related to high dropout and attrition rates as well as high student teacher and section ratios (see discussions in previous paragraphs). These problems existed unsolved yet in the current education system (Amare, 2009; Lemlem, 2010; Tekeste, 2006). The previous imperial and socialist governments were blamed for the lack of relevance and decontextualized contents and delivery methods which again alienated the young Ethiopians from their cultural and social values and norms. Amare (2009), in his study in one of the regions of Ethiopia, Tigray, witnesses that these are still the problems of the current education. The only two issues of the major complaints of previous education systems partly solved in this new policy are increase in access and enrolment as well as language of instruction (Lemlem, 2010; MoE, 2010, 2013; Tekeste, 2006).

As reaction to the above critics and as part of the implementation process of the new education policy, different strategic plans and projects were launched by the government in different periods. Education Sector Development Program (ESDP) is one of the strategies commenced in 1996 as part of the 20 years educational improvement program (Ayalew, 2005). Accordingly, ESDPs I and II brought a significant improvement in expansion and access to primary education (MoE, 2002). However, many of the factors that affect quality and efficiency of education didn't show significant development. For example, the student-textbook ratio was in its alarming situation since it was two books for five students in the primary school and two textbooks for three students in the secondary schools in 2003/4 (Ayalew, 2005). Relevance and contextualization related problems were also not solved as required. So, Bridges et al. (2004) suggested the following important point to overcome the challenges discussed above.

> …..those who are engaged in educational change in Ethiopia might at least make an effort to understand where, as it were, the people whose lives and practices they want to transform are coming from, what understandings they are bringing to their educational experience and what part these understandings play in their ability to cope with the world they live in (p. 542).

The suggestion here is that policy makers and curriculum specialists or any body engaged in educational planning should consider the historical and cultural aspects as well as the current context of the target population or educational stakeholders. Guided by such recommendations, the federal government has been taking some measures and reforming actions to solve the aforementioned shortcomings of the education system. To work out the problems related to the quality of education, for example, the MoE developed a new package of intervention in 2007. This program which is called General Education Quality Improvement Package (GEQIP) encompasses six key areas of intervention: (i) the Teacher Development Program (TDP), (ii) Curriculum Improvement (CI), (iii) Leadership and Management (LM), (iv) the School Improvement Program (SIP), (v) Civics and Ethical Education (CEE), and (VI) Information Communications Technology (ICT) (UNICEF, 2010; MoE, 2008). Moreover, the ESDP IV in particular for education and GTP for all development sectors of the country are two main projects launched by the federal government to improve education and as response to the above problems in the five years period 2010/11-2014/15 (MoFED, 2014).

The current education and training policy of Ethiopia has also put great emphasis on the role of science and mathematics education to create the awareness of applying technology and innovation as the major instruments in creating wealth (MoE, 2010). So, the two documents (ESDP IV and GTP) claimed that science, mathematics and technology are the main determinants of the nation's overall development. That is why these bodies of knowledge are offered at all levels of education (general, TVET, and higher education) to produce competent and productive citizens (MoE, 2010).

In summary, the Ethiopian education system has been growing in many aspects. It was first developed form the unorganized traditional outside church education to non secular but to some extent structured church education. Then, from these traditional inside and outside church education as well as from experience of western education, it grew into the secular and organized type of modern education. Number of schools, colleges, universities as well as enrolment has been also showing a significant increase. Moreover, the importance of science, mathematics, and technology has been also rising from the traditional education's focus only on mathematics to the current government's consideration of Science, Mathematics, Engineering, and Technology education (SMET) as central backbone for the development of every sector in the country.

However, the quality and nature of the textbooks, the quality of teachers, the language of instruction, and the methods of delivery and assessment of school science and mathematics education have been the main challenges until recent times. For example, Cherinet (2008) examined school mathematics and found that there is absence of authentic, relevant and realistic mathematical school tasks in the Ethiopian curriculum/textbooks and instruction.

1.2. Statement of the Problem

School mathematics education has failed to satisfy the needs of most learners due to its rigid view that mathematics is an absolute body of knowledge owned and taught by few mathematicians (Ernest, 1991; Millroy, 1992). In other words, mathematics is believed to be culturally neutral and value free, its educational practices are based only on Western cultures that marginalize other cultures (Bishop, 2008). However, Sociocultural and anthropological studies of mathematical knowledge have greatly influenced research in mathematics and mathematics education in the past few decades (Herron and Barta, 2009). According to Naresh (2008), this gave rise to different areas of research in the field of mathematics education. One of them is the study of out-of-school mathematical practices embedded in everyday activities of a given community. As reviewed and described by Millroy (1992), such studies concluded that, " Research conducted in settings outside of schools shows convincing evidence that people are able to construct mathematical ideas in order to solve problems that they deem to be significant" (p. 50). This shows that people, even those who didn't attend formal education, can construct and use mathematical knowledge in their work related activities of everyday life.

However, Naresh (2008) argues that the mathematics constructed and used by adults in out-of-school work related activities is not explicit in the sense that it is embedded in the activity and covert. One of the issues that the current study was concerned was, therefore, to uncover such mathematical constructions and practices of the Wag Khimra people of Ethiopia and to describe the nature of their workplace mathematics. This is helpful for teachers and other school practitioners to learn with what out-of-school mathematical experience or background that the students come to class and reorganize the lessons accordingly (Wager, 2012).

This study can, therefore, be taken as part of the increasing level of attention in conducting studies in the two situations and support practitioners (students and teachers) of the classroom by providing findings that show the positive interaction between the two settings. Moreover, it can contribute to the increasing need of connecting school mathematics with the learners' sociocultural context by incorporating out-of-school mathematical practices in the classroom (Wager, 2012). With regard to this issue, Millroy (1992) has claimed that

> Rather than dismissing mathematical practices and strategies that develop out of daily activities as lacking in authenticity and rigor, mathematics educators need to study such practices, acknowledging their strengths and seeing their weaknesses as opportunities to negotiate broader understandings in the classroom (p. 50).

Understanding the out-of-school mathematical practices is helpful to know the learners' mathematical background which in turn helps to devise means of connecting the two situations, everyday life and school. Following such calls for research, many related studies have been conducted (Carraher and Schliemann, 2002; Civil, 2002; Moschkovich, 2002; Rowlands, 2008; Smith III, 2005). However, the current literature and empirical studies address only the mathematics of few cultural groups and mathematics of few workplaces. Moreover, people (including mathematics educators) perceive workplace activities need simple or no mathematics to achieve their goals (Naresh, 2008). All these gaps and misconceptions need to be addressed through further research. One such study is the current investigation aimed to understand the everyday mathematical practices in general and workplace mathematics in particular as well as their implications to classroom mathematics teaching and learning.

With regard to Ethiopia, the information reviewed in the background section above shows that the primary education in Ethiopia is in a very good move with respect to enrolment and expansion but no improvement with regard to the quality (MoE, 2010). Teaching materials, delivery methods and relevance of contents to students' real lives are among other indicators of quality. With regard to relevance, although the current education policy of Ethiopia emphasizes the contextualization of the curriculum and instruction in schools, this is not realized in actual classroom level implementation of the policy (Amare, 2009). This shows that school mathematics teaching is divorced from the context and culture of the learners (Adula & Kassahun, 2010; Chernet, 2008; Eleni, 1992). Moreover, the mathematics text books administered in the study site are directly translated from the Amharic versions to the Khimtigna language for the mere purpose of using local language as language of instruction (see chapter four).

The reason for the above claim is that there is no systematic research explicitly focusing on workplace mathematics in connection with mathematics education, comparable to what has been and is being done in other countries, has been carried out in Ethiopia. Therefore, workplace mathematics needs to be studied in the context of Ethiopia and its peoples. This study tried to identify the out-of-school mathematical practices and investigated how these do interact with the school mathematics presented in the classroom by textbooks and teachers by taking the case of the Khimra people.

1.3. Objectives of the Study

The general aim of this study was to gain an understanding of everyday mathematical practice of the Wag khimra People and the means of connecting school mathematics with it. Specifically, the following objectives were addressed:

1. To explore and understand the mathematical ideas and practices in the everyday activities of the Khimra people, Ethiopia.

2. To understand the influence that work and game related activities have on the emergence of mathematical practices and the vice versa.
3. To find out the Interplay between in- and out-of-school mathematics of workplace and game.

The first objective was limited to describing participants' overall work structure and identifying situations that demand their engagement in mathematical computation. The second objective was intended to examine how the work-related activities produce mathematical ideas and procedures, as well as how mathematics helps the successful completion of the goals of the work-oriented activities. The third objective was meant to examine and describe how out-of-school work related mathematics and school mathematics interact in the sense how workplace mathematical ideas are used and influence the classroom learning and how school learned mathematics is used in the out-of-school situations.

1.4. Research Questions of the Study

Based on the problem stated and the objectives of the study given above, the following research questions were forwarded to be addressed in the current study.

1. What is the structure of the overall work-related activities of the participants in each selected workplace and game? How is mathematics embedded in such activity structures?
2. How do the goal-directed activities of the selected workplaces and their inherent mathematical activities influence one another?
3. How do in-and out-of-School mathematical practices interplay? And why do they interact in the way it is?

1.5. Delimitations of the Study

Although ethnomathematics includes vast areas of research in mathematics education (Zhang and Zhang, 2010), this study focused only on the cultural aspect (everyday mathematics in broader sense and workplace mathematics in particular). The workplaces include pottery, knitting craft, farming, house building, traditional brewing, shop, shoeshine, and weaving. 'Geveta' and 'tirga' were the only games examined. So, only the mathematical practices in these workplaces and plays or games were investigated. In this paper, except for other purposes and discussions, terms or phrases 'outside school' or 'out-of-school' are not used to show the settings/contexts of this study. Instead, in order to limit the scope, the phrases 'workplace setting' and 'game/play settings' are used throughout this paper to refer the context/settings studied/considered in this study. This is because outside school or out-of-school settings/contexts include many aspects such as workplaces, game/play, church, home, gathering, and so on, but only workplace and game settings are studied. Regarding to Mathematics teaching and learning classrooms, the study focused only on second cycle (5^{th}-6^{th} grade) of two primary schools. The reason was that the researcher believed that it was important to focus on small issue in depth than getting surface information of wider areas and issues. First cycle (grades 1-4) was not chosen as main target because it is difficult to get qualitative data from the students of these grades as their age and school experience is in a very early stage.

In trying to investigate the interplay between cultural mathematics and school mathematics of the classroom instruction, the study did not make an intervention using pretest and posttest experiments. Instead the actual classroom practices including activities, interactions, and contents or topics of discussions were observed. Individual interviews with teachers and students as well as analysis of mathematics textbooks and teacher guides of these two grade levels were conducted in order to compare with the real life mathematical practices studied in workplaces and to show the possible interrelationships.

1.6. Limitations of the Study

There are some limitations that can be assumed to affect the study. One limitation arises due to the fact that the study's design was a qualitative case study design since generalizing from particular workplace and school studies of a zone to national or global level can be exaggeration (Yin, 2003). The limitation is that it is difficult to generalize results of this study to Ethiopia or to Amhara regional state.

The short time of interview and observations stayed in contact with the participants and their activities might have also affected the depth of the data and hence the findings of the study. This shows that the study was not an ethnographic study while the topic is related to cultural practices. The data and the findings would have been deep and rich if long period ethnographic study was conducted. Moreover, as the researcher was seen as outsider (especially in classroom observations), the students might have been reluctant to perform their usual classroom activities such as discussion. This might have influenced the findings.

Further, the current study did not consider the mathematics practiced in religious institutions as well as the historical development of the mathematics practiced in the workplaces. This is another limitation that might have affected the study's findings.

1.7. Theoretical Framework

Constructivism (both radical and social) and ethnomathematics have common views with regard to mathematics curriculum and instruction because both of them claim that students should actively participate in the knowledge construction process within their sociocultural context (Cobb, 1994; Eglash, 1997). So, this study was mainly guided by the sociocultural perspectives since it focuses on mathematical practices and cognition in workplaces within their socio-cultural contexts. The basic assumption of sociocultural theory is that "human consciousness is a mediated mental activity" (Allahyar and Nazari, 2012; p. 81). This implies that there are two pointes to be noticed. The first point is about the human consciousness and mental activity which in turn refer to the individual. The second part informs about the things external to the individual which includes social and physical environment. Thus, choosing sociocultural theory as guiding perspective does not necessarily ignore the role of the individual in the research process. This leads to the argument that it is possible for a researcher to use a combined perspective of radical or individual constructivism (Von Glasersfeld, 1995) and sociocultural theory or social constructivism (Ernest, 1991; Pritchard and Woollard, 2010).

Epistemologically, social constructivism emphasizes on the interactive construction of knowledge and the socio-culturally situated nature of mathematical activity and discourse (Cobb, 1994; Pritchard and Woollard, 2010). But radical constructivism focuses on the cognitive individual and mental construction of knowledge through a process called intellectual adaptation while the individual is kept in action on the environment around him/her (Millroy, 1992). The principle of social constructivism is derived from the sociology of knowledge whereas that of radical constructivism magnifies the role of individual knowledge. Ontologically, social constructivism asserts that reality is constructed inter-subjectively through social negotiation between an individual and significant others who are able to share meanings and social perspectives of a common life-world (Jaworski, 1994). However, the reality of radical constructivism is constructed by the individual based on his/her experience and publicized for feedback and confirmation (Millroy, 1992).

Despite the above differences, the radical and social constructivists agree that reality is not out there to be discovered but it is constructed or invented by individual or social actions within a given experience and context (Cobb, 1994; Jaworski, 1994; Pitchard and Woollard, 2010). Another point of concurrency is that both Vygotsky's sociocultural theory and that of Piaget's individual cognition theory highlight the crucial role that activity plays in the learning and development of the child though they still differ on the type of activity (Cobb, 1994). Based on such common points, Cobb concluded the possible coordination of the two perspectives by arguing on von Glasersfeld's 'hammering' metaphor. Von Glasersfeld used this metaphor to explain the concepts such as perturbation, empirical abstraction and accommodation (see von Glasersfeld, 1995 for details of these concepts) when defending radical constructivism. However, Cobb argued that since the hammer and nail are cultural artifacts, the individual engaged in the practice of hammering is not free of sociocultural interactions and influences (Cobb, 1994). This shows that, regardless of which comes first and after, the two perspectives can complement one another.

According to the social constructivists, the developing or learning individual or child should appropriate and internalize a cultural form (Cobb, 1994; Lave and Wenger, 1996). However, it is not clear that how a cultural form that is external to the child is brought across the barriers and become internal and cognitive form. This weakness of social constructivists is solved by the radical constructivists that suggest the child needs to reorganize his/her activity in order to overcome this difficulty (Cobb, 1994). Similarly, how the individual reorganizes his/her activity is a question that needs to be addressed by the radical constructivists. The sociocultural perspective complements the individual constructivists by suggesting a solution to this problem. The solution is that the novice child reorganizes his/her activity while attempting to achieve objectives that emerge in the course of his/her participation in the practice of economic exchange that is social interaction (Saxe, 1991).

These points of concurrence and coordination between the two perspectives provide opportunities to see and use their combination (in the sense of complementing one another) in research investigations. This coordination of individual and social perspectives can be understood easily from D'Ambrosio's (2009) humanness triangle. At the vertices of this triangle are individual, nature, and others (society). The sides of the triangle carry the mediators that facilitate the mutual interaction between a pair of these three aspects at the vertices. Accordingly, individuals interact with nature through instruments, society and nature interact through production process, and individuals interact with society via language (D'Ambrosio, 2009). Still the mediators interact with one another. For example, instruments (including new thoughts and concepts of intellect and material tools) are communicated through language and have important role in the production process, language is also helpful in defining and describing production processes (ibid). According to D'Ambrosio (2009), this solidarity and interaction of the three intermediaries of the humanness triangle form culture. Thus, the humanness triangle does not explicitly clarify which theory comes first and which follows, but the coordination and mutual interplay between the individual and social theories is emphasized.

Moreover, according to Cobb (1994), mathematics learning and doing is a process of both active individual construction and enculturation into the mathematical practices of wider society. This is similar to Ernest's (1991) argument about the objective-subjective knowledge construction process. Individuals actively construct subjective knowledge when they interact and experience the world around them. Then this subjective knowledge becomes acceptable and objective knowledge when there is negotiation with others through communication, reflection, evaluation and discussion (Ernest, 1991; Cobb, 1994). In other words, individually constructed mathematical knowledge is accepted as knowledge when it is recognized and used by other(s) in the society and socially developed knowledge is owned and internalized by individuals when they apply it in their life activities.

This complementariness between the sociocultural and radical constructivists' views is used as an opportunity to guide the current study. Saxe (1991) believed in and used the complementarities of the radical and social constructivist perspectives as a combined lens in his research. Therefore, epistemologically and ontologically, this study is influenced by both aspects of constructivism-the radical and social. Their combination helped to see the situation in different angles such as the role of the individual person, the contribution of the social context, and the contribution of the physical and material world where activities are performed. This is similar to what Saxe (1991) used but in different situation and to different participants.

In previous and coming discussions of this paper, culture is repeatedly mentioned. So, it is necessary to define and clarify what culture. Citing White (1959), Bishop (1988) identified four components of culture. The first factor is an ideological component concerned with beliefs and philosophies, whereas the second variable is sociological component that includes social customs and institutions as well as rules and patterns of interpersonal behaviors. The third is sentimental component which deals individual person's attitudes, behaviors and feelings about people. The last one is technological component that deals with tools and artifacts together with their use in manufacturing (Bishop, 1988). Of all the four factors of component, the technological one is considered as the major and influential one on which the other components depend. D'Ambrosio's (2009) components of culture look somewhat different from these four factors as he reduced them into three components namely language, instrument, and production (See previous paragraphs). Moreover, D'Ambrosio (1985, 1990) defines culture, more specifically, in terms of small group of people such as labor group (see chapter two) with common belief, goals, activities, behavior and language. However, the above components also show that culture is also owned and practiced by larger ethnic group that is capable of self-sustaining and producing new generations without depending on others (Mesoudi, 2011). In the context of the current study, culture refers to the characteristics and knowledge of a particular group of people and includes language, beliefs and values, social habits, music and arts, 'manifacts' (intellectual perspectives used as tools), artifacts (material tools), and individual personalities that are developed throughout the history and affect the everyday life activities and behavior of the people (Bishop, 1988; Chikodzi and Nyota, 2010; D'Ambrosio, 1985; Mesoudi, 2011).

Different ethnomathematicians studied the cultural practices of mathematics in relation to mathematics education in different countries (D'Ambrosio, 1985; Gerdes, 1988; Masingila, 1994; Saxe, 1991; Zaslavesky, 1970), and have also developed their own frameworks to study mathematical practices in different cultural groups. The guiding perspective for almost all these studies is constructivism (Brenner, 1985; Cobb, 1994; Cuvil, 2002; Lave, 1988; Millroy, 1992; Saxe, 1991). It is possible and important to mention some models or research frameworks developed and used in previous studies of this kind.

Lave's (1988) apprenticeship and situated learning theory defines learning as practice of knowing within a social interaction and co-participation in activities with significant others. Millroy (1992) also adds that, in this apprenticeship learning theory, the learner needs to observe another able person doing the activity and then take turn to try it within that context with the help of the master. According to this apprenticeship theory of learning, a researcher might be engaged in the workplaces of participants and the participants become masters for the researcher as a student (Millroy, 1992).

Bishop (1988), based on a long period research experience, categorized the mathematical ideas and practices performed in any culture or nation in six themes. The first one is counting which includes tallying using objects for recording and special number words and names. The second category is locating through models, diagrams, drawings, words or other means to explore one's spatial environment. The third is measurement that quantifies qualities for the purpose of comparison and ordering. Designing to create a shape for an object by symbolizing it in some conventional way is the fourth theme. Whereas the fifth is playing by engaging in games and pastimes with rules to be obeyed, the sixth category deals about explaining a phenomenon.

Barton (1996) also identifies theoretical frameworks that influence ethnomathematical studies in two ways. The first framework is put in terms of the dimensions of ethnomathematics the time dimension (history of mathematics), the cultural dimension (cultural practices of mathematics), and the mathematical dimension (relationship of mathematical ideas within mathematics itself). The second framework is put in terms of ethnomathematical activities of the person who studies ethnomathematics: descriptive activities (describing the activities studied), archeological activities (uncovering the mathematical aspects of the activities), mathematizing activities (relating the mathematical aspects uncovered to the existing mathematical concepts) and analytic activities (explaining why the practices are in the way they are).

Another widely used frame work to study ethnomathematics is that of Saxe's (1991) analytical framework (Cobb, 1994; Saxe and Bermudez, 1996; Naresh, 2008). According to Masingila, Davidenko, and Prus-Wisniowska (1996), Saxe's analytical framework is not only important as a method for studying the interaction between cognitive and socio-cultural developmental processes but it is also helpful in trying to connect in- and out-of-school mathematical learning and practice.

According to Masingila (1994), it is possible for the conceptualization, design and conduct of a study like this to be guided and influenced by three or more frameworks such as conceptual, theoretical and methodological perspectives at the same time. However Saxe's (1991) framework and Bishop's (1988) classification of environmental mathematics are the ones used in this study, but why not the other frameworks? The reasons are the following. If Lave's (1988) apprenticeship framework is considered, it was not appropriate to this study because there were no master-student divisions among the practitioners of the workplaces selected. Moreover, the researcher didn't choose his research methodology to be ethnographic study that needs long time field stay so that the researcher could be a learner and the participants of the research to be masters for using this aforementioned framework rather it is a case study. However, this doesn't mean that the researcher didn't learn from the participants because the data collection by itself was a process of learning. Although the cultural dimension of Barton's (1996) first framework goes with the purpose of this study, it was not used as this study didn't consider the other dimensions such as historical development of mathematics in scope.

Although Bishop's (1988) categorization of mathematical practices in cultural groups was used to guide the development of the themes related to documenting the mathematical ideas in the studied workplaces and games, Saxe's (1991) model was the major framework employed. This is because it touches most of the above frameworks and is suitable to address all the research questions of the study. Saxe developed the three component theory in range of researches he conducted on the Oksapmin people of Papa New Guinea in 1980s. He uncovered that these people had their own unique number system with each number has representation on body parts and they used this 27 number system counting and arithmetic computations even in modern trade and banks (Saxe, 1991). He realized that neither Piaget's cognitive constructivism nor Vygotsky's social constructivism can separately produce sufficient results in such studies because the former lacks the social context and the latter gives less emphasis on the role of individual cognition. Hence, the framework was founded on both constructivists for the purpose of investigating candy seller children's mathematical practices in Brazil (Naresh, 2008). After he himself used this model in his candy selling research, other researchers of the field employed this framework in other situations and research questions. Two examples are the use of this framework by Masingila, Davidenko, & Prus-Wisniowska (1996) in their analysis and interpretation of the carpet laying workplace mathematics and Naresh's (2008) case study of bus conductors' mathematical practices in India. This framework has three analytical components.

Component I: Practice-Linked Emergent Mathematical Goals

According to Saxe (1991), while one may have a general plan of approach and target at the beginning of the activity, many goals and related approaches emerge at any stage of the activity due to the demands of the situation and that stage. He describes this as, "goals are emergent phenomena, shifting and taking new form as individuals use their knowledge and skills alone and in interaction with other to organize their immediate contexts." (p.17). There are four parameters that play important roles in the emergence and fading out of practice-linked goals and activities as shown in the model of figure 1.

The first parameter, activity structure, consists of the tasks that must be accomplished in the activity and entails the activity's prescribed objectives and rules or procedure that have implications for children's emergent goals. It also includes the motives related to the tasks. These motives and tasks to be accomplished require tools such as mathematics to finish stage by stage. The second parameter is about conventions and artifacts. These are cultural forms that have been developed over the course of the socio-history of the cyclical activity structure. Counting systems and currency systems are among such social conventions and artifacts common in most workplaces. Sometimes individuals within a culture also develop a set of conventions and artifacts that may be unique to their particular situation.

Social interactions such as master-apprentice relationships constitute the third parameter. For example, a shop owner may help his/her customers with the computations such as adding coins related to decimals during the buying and selling process (Saxe, 1991). In a carpet laying context, the discussion and interaction between the installers and helpers often allowed helpers to engage in activities they would not have been able to accomplish unassisted (Massigila, 1993). These assistances are directly related to emerging of goals and sub-goals that practitioners accomplish in the practice. The fourth parameter is the prior understandings that individuals bring to use on cultural practices. These prior experiences may both constrain and enable the goals they construct in practices.

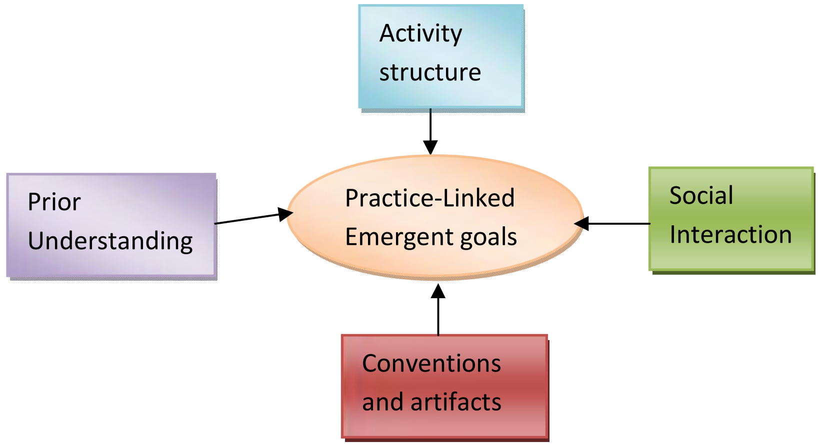


Figure 1: Saxe's four parameter model to analyze emergent goals of activity (Saxe, 1991: 17)

Component II: Form-Function Shifts in Cognitive Development

The second component deals about the shifts of historically elaborated cultural constructs and social conventions to cognitive forms and functions during the course of practice in the activity. Masingila et al (1996) provided an explanation for this component in their context of carpet laying activity as follows:

> …. One convention that was present in this context was an algorithm for laying tile. The algorithm was an agreed upon procedure for laying tile so that the tile was lengthwise and widthwise symmetrical about the center of the room and that fill (partial) pieces were at least six inches wide. However, as the helper participated in the tiling process and, as was sometimes the case, became an installer, the procedure (form) became a cognitive tool (function) to be used for making decisions in complicating factors compounded the installation (p. 192).

This shows that cultural forms that exist in the practice shift to cognitive functions for the apprentice who learns the skills by observing the master and then practicing. According to Saxe (1991), cultural forms are "historically elaborated constructions like number systems, currency systems, and social conventions" (p. 19). When these forms are acquired and used by individuals who practice the tasks, they become cognitive functions such as counting and arithmetic which emerge to accomplish the activities and motives.

Component III: the Interplay between learning across Contexts

Component three analyzes the influence of school based knowledge on everyday life activities and conversely. Saxe calls this component as transfer of learning in either direction. That is if the individual is in out-of-school activities, he/she can use school learned mathematical ideas and procedures to successfully accomplish the work and if he/she is engaged in classroom mathematical task, then he/she can make use of out-of-school experiences (Masingila, et al, 1996; Naresh, 2008).

According to Saxe (1991), in order to analyze and understand adequately the interplay between learning across contexts/practices, "we must achieve some understanding of the similarities and differences in emerging goals within the practices (component one); we also must achieve some understanding of the form-function shifts that may be linked to participation in each practice (component 2) " (p. 22). Therefore, understanding the first two components helps to understand the third component. Saxe is also using the analogy of practice vs. theory to explain the difference and similarity between in-school and out-of-school mathematics. So, whereas practical mathematics is an instrument to achieve a larger goal in workplace, theoretical mathematical knowledge of school is complete in itself and not used as a tool.

The three components of Saxe's (1991) framework were used to analyze the data collected in answering the research questions and achieve purposes of this study. Using component one, the goal oriented activities in workplaces and classrooms were examined in order to address the first research question by analyzing the mathematics practiced by the workers in the workplaces as well as students and teachers in school. Using the second and third components, the interactions of out-of-school and in-school mathematical practices were studied to address the third research question, as well as in interpreting the data and findings.

1.8. Significance of the Study

This study is significant in several ways. The first importance is that the target population will get the opportunity to expose its mathematics related cultural practices to the external world via this study's documentation of results and dissemination of knowledge.

The second importance is that the findings of this study will present the outside school mathematical practices to inform mathematics teachers and curriculum specialists that mathematics and mathematical practices are not only those written by great mathematicians of the western society in books and journals but students also bring their own mathematical knowledge from their out-of-school environment to classroom (Bishop, 1988). Once the mathematics related objects, games, and ideas of the indigenous peoples are identified and unlocked by this study, it will be easy to access for teachers, curriculum developers, and policymakers to get deep information and understanding of the mathematical practices in the everyday activities of the peoples (the Khimra peoples in this case) and use them in their practices to improve the mathematics instruction and curriculum.

The third essence of this study is in showing the relationship between ethnomathematics and mathematics instruction or between culture and mathematics. With regard to this issue, there is a widespread agreement about the close relationship between mathematics teaching and students' mathematics related cultural values. For example, the NCTM (2000) pointed out that "effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (p.11). This is a contribution to mathematical knowledge and literature. Since mathematical thinking and learning occurs in every culture, it is important to study the mathematics practiced by different cultural groups so that to widen the field of mathematics education (Ascher, 2002).

The fourth importance of this study is in contributing to initiate national ethnomathematics projects by presenting inputs for further study with regard to ethnomathematics in Ethiopia. It will be a stepping stone for Ethiopian mathematicians and mathematics educators who want to carry out further interventions on this issue. Since this study is first of its kind in Ethiopia, it will contribute for novice researchers and PhD students of mathematics and mathematics education to take this field of ethnomathematics as one thematic area.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

"When are we ever going to use this?" (Glazer and McConnell, 2002; ix)

This question reminded me a friend of mine when I was in grade seven. Our mathematics teacher of that time was very excellent in his presentation of the concepts and the ways he solved problems in class. One day, when this teacher was teaching about the base number system such as base two, base three and converting from one base to the other, my friend asked the teacher, "Teacher! If we learn numbers, that is good because we use them in our life such as in the market, when we learn the operations on numbers still well because we count, add, subtract, and divide money or cattle or other objects, but we are now learning about these base number system, when and how will we use them in our life out of this school?" Other students in our class laughed at this question but the teacher tried to mention the application of this concept in military science. This experience of mine is similar to Aikenhead's (2006) description of conventional school science as follows:

> By convention, school science has traditionally attempted to prepare students for the next level of science courses by focusing on intellectual knowledge acquisition. Its ultimate purpose has been to funnel capable students into science and engineering degree programs, a phenomenon or ideology often called "the pipeline" The traditional science curriculum advocates canonical science content and habits of mind (i.e., thinking and believing like a scientist). Students most often do not feel comfortable in this scientist-oriented ideology and experience school science as a foreign culture. They would prefer a science education for everyday life. (p. 1).

This shows that the traditional curriculum and instruction focuses on producing mathematicians rather than equipping skills how to apply mathematical concepts in real-life so that to create mathematics educators. In other words, school mathematics is taught for the purpose of screening to decide which students to continue higher education and which ones to dropout for they couldn't pass the objective and summative assessment tests. This dropout includes getting ride of the entire education not only from mathematics department because if they fail mathematics tests, it is over since mathematics is compulsory. So, the traditional methods of curriculum organization and instruction help the system and officials but not the learners. Throughout this chapter, traditional curriculum or education is mentioned to show the educational practices that use old methods and do not follow new reforms, theories, innovations and technologies in organizing contents and instructional methods. For example, in such traditional education, the teaching method is a transmission model of teaching that views teaching as transmission of knowledge from the teacher to learners (Boaler, 2002).

This chapter reviews the literature to conceptualize the interaction of school mathematical practices with the out-of-school workplace mathematics. It is organized into four sections. The first section discusses the three learning theories i.e. behavioral, cognitive and constructive together with their philosophical backgrounds. The second section conceptualizes mathematics education in the lenses of these learning theories. Under this section, mathematics learning, teaching and curriculum issues are reviewed from the literature. The third section is concerned with Ethnomathematics and some of its branches such as everyday and workplace mathematics. The mathematical practices and ideas of different cultural groups are described from the literature's point of view under this section. The fourth section deals with and provides empirical research studies conducted in relation to everyday and workplace mathematics. The workplace mathematics, students' out-of-school mathematical experiences, and the interplay of indigenous everyday mathematics with school mathematical practices are briefed with examples from previous empirical studies conducted in different countries and settings. The fifth and final section reviews ethnomathematics related works particular to Africa and its peoples.

2.1. Learning Theories

Educational system is always a philosophy driven practice where policy makers and curriculum developers choose contents and methods that suit their ideology (Barrow and Woods, 2006). Rationalism and empiricism are among the ideologies that influence educational decisions and practices. Rationalists such as Plato and Kant are dualists that view mind and matter or psychological and physical worlds as different realities (Carr, 2003). Empiricists such as Aristotle, Russell and Dewey are, however, monists who believe that the mental and physical realities are connected if not identical. Among the earlier educational theories emerged from the above ideologies are behavioral and cognitive views.

Behaviorism is a learning theory that emphasizes on the stimulus-response configuration of education (Carr, 2003, Pritchard and Woollard, 2010). According to Pritchard (2009), behaviorism focuses on observable behavior and discounts learning that involves any mental activity. Advocates of behaviorism such as Skinner, argue that learning occurs in a stimulus-response structure, which they call programmed learning (Clemson & Clemson, 1994). The main limitation of the behaviorist conception of learning is its focus on observable stimulus and its associated behavioral change but not considering the basic components of knowledge such as understanding, reasoning and thinking (Ertmer and Newby, 2013). Scott (2001:14) describes this limitation of the behaviorist perspective:

> It follows that distinctions between rote learning and learning with understanding are not considered—what is needed is to deliver appropriate stimuli, teach by repetition and then reward the appropriate responses. Related assumptions are that a complex skill can be taught by breaking it up and teaching and testing the pieces separately; and that an idea that is common to

> action in many contexts can be taught most economically by presenting it in abstract isolation so that it can then be deployed in many situations. A test composed of many short, "atomized," out-of-context questions, and "teaching to the test," are both consistent with this approach.

Therefore, behaviorist teaching is transmitting abstract knowledge from the so called knowledgeable teacher to students, who are supposed as 'empty vessel', to show observable behavioral change and development. It is clear, thus, that students simply sit in the classroom in front of the teacher, listen what he or she says, take notes, read the notes and prepare for test so that decision could be made whether to promote to the next grade or not based on the results of the conventional mid and final exams. Moreover, it is criticized that repeated rewards to a particular student may annoy other learners in the classroom and such reward may cause loss of interest on the part of the learners (Pritchard, 2009).

Based on the claim that learning "focuses on the mechanical association of physiological reflexes that the instrumental, purposive and operant conditioning", behaviorists argue that "genuine learning occurs only when behavior adapts to environmental pressure in the interests of furthering the survival-related ends and goals of the conditioned-life form" (Carr, 2003; p. 88). This behaviorist philosophy of education didn't recognize the role of the individual learner in the teaching and learning process. Moreover, there is a fixed curriculum model that revolves only around the content and the method of teaching is teacher-centered (Cherinet, 2008; Adula and Kassahun, 2010). Consequently, such failures of the education systems of nations to address the learners' problems due to reliance on this theory were challenged by researchers and reformists so that recommending new alternatives among which is the cognitive theory (Carr, 2003; Ertmer and Newby, 2013).

The cognitive learning theory emerged to put the individual learner at the center of educational activities such as policy formulation, curriculum development and instructional pedagogies (Carr, 2003; Clemson and Clemson, 1994; Pritchard & Woollard, 2010). The cognitive theory relates learning with the development of schemata to link what we know already with our new learning (Clemson and Clemson, 1994). This theory, although accepts the behavioral habituation or conditioning as one kind of goal oriented behavioral change, arose in denying that rational agency is reducible to behavioral habituation agency (Carr, 2003). Another point of concurrence between the cognitive and behavioral theorists is that both emphasize on giving the child opportunities in learning (Clemson and Clemson, 1994). However, the big difference between these theories is on the role of the individual cognition. Behaviorists account for the semantic or meaning-implicated aspects of learning in the words of Carr (2003: 100) "learning presupposed to human education entails some *understanding* of what is learned, and understanding is a matter of a grasp of its meaning." *But, c*ognitive theorists such as Piaget and Bruner argue that "human meaning making cannot be entirely explained in terms of behavioral processes because understanding is a matter of active imposition of meaning" in the sense that "intuitions without concepts are blind" and the conceptual understanding can be realized through active engagement of the learner's mind..

According to the advocates of cognitive theory it is not only the external or environmental stimulus that is important to the behavioral change or understanding of the child about the concept taught. The mental restructuring and organization of the new concept in relation to existing experiential knowledge is also essential component of learning (Carr, 2003; Clemson and Clemson, 1994; Cobb, 1994). Although cognitive theorists, like behaviorist, view that knowledge is absolute and objective, they try to connect new concepts to the learner's internal or external world's experiences (Adula and Kassahun, 2010). Individual cognition is emphasized while the active involvement of the learner on the goal-oriented activity is equally valued for the construction of knowledge (Pritchard and Woollard, 2010). This focus on individual learner's role of learning gave rise to the emergence of radical constructivism.

The history of constructivist view can be traced back to thousands of years ago in the thoughts of Gautama Budha (560-477 BC) of India and Heraclitus of Greek (535-474 BC) for they argued that ontological reality is not outside the individual mind's construction (Pritchard and Woollard, 2010). Gautama Budha and Heraclitus both claimed that the facts of outer world are interpreted by the individual and we make the world with our thoughts (Pritchard and Woollard, 2010)). However, constructivism as a theory was formalized in the 20th century by educators through a formal path of writing which originates from research. That is why individual constructivism, also called radical constructivism, is credited to the works of Piaget who conducted research on children and forwarded the intellectual developmental theory of children and adults to cover four stages or levels viz. sensorimotor, pre-operational, concrete operational and formal operations (Carr, 2003; Pritchard and Woollard, 2010; Simatwa, 2010).

In addition to these developmental stages, Piaget introduced the concepts of schema, assimilation, accommodation and equilibration (von Glasersfeld, 1995). A schema is the structural organization of an individual's experiential knowledge in its mind (Jaworski, 1994; von Glasersfeld, 1995). When the child interacts with the environment and if this experiential situation satisfies the conditions that characterize it in the existing scheme, it is recognized as fit to the scheme. In this case assimilation is said to be occurred. If the child is unable to assimilate this experiential situation, there will be a perturbation which may lead to any type of reaction. If the situation is yet retrievable, it may be reviewed.

> This review may reveal characteristics that were disregarded by assimilation. If the unexpected outcome of the activity was disappointing, one or more of the newly noticed characteristics may effect a change in the recognition pattern and thus in the conditions that will trigger the activity in the future. Alternatively, if the unexpected outcome was pleasant or interesting, a new recognition pattern may be formed to include the new characteristic, and this will constitute a new scheme. In both cases there would be an act of learning and we would speak of an 'accommodation' (von Glasersfeld, 1995: 65).

Accommodation is, therefore, a process of learning that alters a schema in order to allow the recognition of new information that contradicts with the existing characteristics of the schema or having more or less features than those characterizing the existing schema. The following paragraph provides examples of each concept defined here.

For example, assume an individual has a general knowledge that a square is a parallelogram with all sides and angles equal. This is a schema. If the individual encounters other figures which satisfy this characteristic and definition but different sizes or colors, he/she will add to the existing knowledge since the definition is not violated. This is assimilation. If the same individual, through experience/experimentation, finds a parallelogram with equal sides but variation in angle measures, he/she gets confused with the criteria of equal angles because this new figure could not satisfy this feature of squares, cognitive conflict is created. So, this individual will alter the existing schema of squares in order to allow the new knowledge to be added by creating sub schemas (squares and rhombuses) under the schema of figures with equal sides, accommodation. By reorganizing the existing schema when contradicting information comes in or by simply adding if the new knowledge does not contradict with the already existing knowledge, the individual reaches equilibrium (Pritchard and Woollard, 2010; Von Glaserfeld, 1995).

According to the constructivists such as Piaget and Bruner, learning is an active process in which an individual constructs new ideas based upon their present and pre-existing experience. Put differently, learning is dependent on the experience (prior knowledge about the lesson), how the individual learner interprets the concept presented in the lesson, and on how the learner undertakes the activities provided in the lesson (Pritchard and Woollard, 2010). This shows that it is possible for different individuals exposed to the same learning experience/concept to have different understanding of the reality in the lesson due to the differences they have on the issues listed in the previous statement (Pritchard and Woollard, 2010).

Individual constructivism focuses on the individual cognition of new information while interacting with the environment and making use of his/her own previous experience in relation to the new concept. Von Glasersfeld (1984) describes radical constructivism in relation to individual cognition as follows:

> Constructivism necessarily begins with the (intuitively confirmed) assumption that all cognitive activity takes place within the experiential world of a goal-directed consciousness. Goal-directedness, in this context has, of course, nothing to do with goals in an "external" reality. The goals involved here arise for no other reason than this: a cognitive organism evaluates its experiences, and because it evaluates them, it tends to repeat certain ones and to avoid others (p. 10).

This shows that both cognitive theory and radical constructivism focus on the role of the individual learner in the lesson. However, like the cognitive perspective, radical constructivism ignores the role of the social context and culture in the knowledge construction process of individual learners. Consequently, one of the critics posed on individual constructivism is that since skeptics claims that there is no absolute knowledge to appeal to, then the knowledge constructed by everybody must be equally valid (Millroy, 1992). As a solution to these criticisms and problems, an important idea was added, "the role of others" in the construction process. And this social aspect of constructivism is called social constructivism and came in to being as a remedy for the drawback and critics of cognitive or radical constructivism.

According to the social constructivist perspective, people try to reach some consensus of meaning about their personal constructs of knowledge or ideas through communication, argumentation and negotiation with others within the community (Millroy, 1992). Both radical and social constructivists agree that reality is not waiting there outside the human mind to be discovered but it is to be made by human mind. They also concur that knowledge is constructed and invented, and not discovered. However, they differ on the method and process of construction (Carr, 2003; Millroy, 1992).

Thus, social constructivists' epistemology claims that knowledge is a human creation in which meanings and understanding are created by means of social and cultural interactions, as well as interaction with physical environment (Carr, 2003; Millroy, 1992; Pritchard and Woollard, 2010). According to the social constructivists such as Vygotsky, learning is neither an individual nor passive process; rather it is a social process which depends on interaction with others, cultural context, and pre-existing experience of the learner (Ernst, 1991; Millroy, 1992). It is important, therefore, to mention Vygotsky's Zone of Proximal Development (ZPD) which describes the difference between an individual can learn a concept on his/her own and what this person can learn when he/she is supported by a more knowledgeable other (Newman and Holzman, 1993; Jaworski, 1994). Unlike Piaget, who claims that intra psychological learning comes first and then social interaction for confirmation of the already constructed idea, Vygotsky argues that learning occurs first in the social interaction with more knowledgeable people and then this knowledge is more advanced in the individual learner's mental process (Newman & Holzman, 1993).

Although constructivism, as a learning theory, influenced educational innovations to exist and has many educators and researchers of our time as advocators, there is no a consensus reached on which comes first and which follows, the individual learning plane or the social learning one? The answer to this question is philosophical and beyond the scope of the current study since it needs its own empirical investigation and argument in a separate topic. Therefore, no matter what the order is, the constructivist theory plays an important role in education since it puts the learner at the center of educational planning and practice. Since teaching and learning is learner-centered, the constructivist teacher is a facilitator that helps students to identify problems and work on solutions (Cherinet, 2008). So, constructivists' curriculum and instruction should base their organization and presentation of contents on the students' socio-cultural and environmental contexts and to make use of students' experiential background (Pritchard and Woollard, 2010).

How can mathematics education be viewed in relation to the previously discussed theories of learning? Which theory of learning and the philosophy behind it contains ideas and suggestions how to contextualize mathematics education. These questions and other related issues are addressed in the section below.

2.2. Mathematics Education

Mathematics education is one stream of education that studies about how people learn and do mathematics (Dörfler, 2003). It tried to reform itself according to the new educational innovations and reforms discussed above. These reforms include shifts from teacher-centered and conditioned behavioral change of the behaviorist theory to the development due to the combination of external motivator and internal thinking of the learner that cognitive theorists suggested. Further shift also showed that students' effective learning is not achievable through the mere combination of external condition and internal thinking and a third factor should be included. That third factor is learning by doing (Adula and Kassahun, 2010; Amare, 2009). Therefore, the reforms in education at large and mathematics education in particular are influenced by the above three issues, behavior, cognition and action.

The reforms of mathematics education take different forms or names such as culturally relevant mathematics curriculum or pedagogy (Rosa & Orey, 2010), realistic mathematics education (Heuvel-Panhuizen & Wijers, 2005), humanistic mathematics education (Aikenhead, 2006), connected mathematics teaching (Sawyer, 2008), and Ethnomathematics (D'Ambrosio, 1985; Rosa and Orey, 2010). But all talk similar issue, relating mathematical concepts to students' background and culture. The reason for the worry of mathematics education researchers and educators to develop such reforms is because of the observed low achievements in and poor understandings of mathematics by students (Achor, Imoko, & Uloko, 2009). But still mathematics is considered one of the core subjects in schools and other educational institutions (Orton & Frobisher, 1995). To solve such problems, therefore, the school mathematics curriculum and instruction should be designed in such a way that the contents and knowledge domain presented encourage the students use their potentials and cultural experiences.

To suggest such innovative mathematics curricula and instruction, the traditional education need to be studied first. Advocates of the innovation of culturally relevant mathematics education have, therefore, researched the practices of the traditional mathematics curriculum (Aikenhead, 2006) and identified some of its main failures. One failure is that there is a rapidly declining student enrolment in science and mathematics related fields because of the negative attitudes that students developed in previous school science and mathematics education (Adula and Kassahun, 2010).

These are results of frustrations due to low achievement which in turn is caused by the teachers' non utilization of appropriate teaching approaches and pedagogies (Achor et al., 2009). These negative attitudes towards mathematics have caused students to perceive mathematics to be socially sterile, impersonal, frustrating, and dismissive of their real-life-worlds and career goals (Aikenhead, 2006; Ezeife, 2002).

A second failure is its cultural alienation of the learners in the sense that it is devoid of the socio-cultural and environmental contexts where the students come from (Aikenhead, 2006; Bishop, 2008; D'Ambrosio, 2006; Gerdes, 1988). Still a third limitation of the traditional curriculum, which is similar to the second, is lack of relevance and adequate pedagogy. This is because the canonical mathematics contents in the curriculum and instruction are not in a way that they are useable in out-of-school situations that need mathematics (Aikenhead, 2006). Researchers also argue that the curricula of nations in the previous colonial regimes were designed to fulfill the needs of the ruling elites whose children are supposed to continue their higher education in colleges and universities of western countries (Taylor, 1991). And hence their contents and examples are based on western cultures with no relevance to the local peoples and learners (Taylor, 1991).

While countries restored their independence, they still maintained similar educational practices as in the colonial period and provide canonical type of contents to prepare their nations' children for university. Bishop (1997) explained this as follows:

> In general the curriculum which applies in most countries of the world is not well suited to the introduction of cultural perspectives. It is a curriculum structure which has evolved to suit the mathematical preparation of students for further mathematical study at university. However when we consider the majority of school pupils who will never go on to study mathematics at university, this so-called preparation is shown to be very inappropriate (p. 6).

This means that students need the immediate importance of mathematics learning. And the immediate importance and priority for the students is the relation between the real life they are living and the concepts introduced at their school. Preparation for advanced education should be a second objective (Aikenhead, 2006). Taylor (1991) describes the disconnection between the out-of-school world and school practices as,

> The school mathematics curriculum, around the world, is failing in one of its main aims: to facilitate the logical and accurate solution of problems encountered in the spheres of work, leisure, and other daily activities (p. 108).

The school mathematics curricula not only ignore the local conditions and contexts but also they are inappropriate to the learners' socio-economic world and this caused high degree of mathematics anxiety, failure rates, and disjuncture between school mathematical tasks and real world mathematical activities (Aikenhead, 2006).

According to Lave (1988), the disconnection between school and out-of-school mathematics lies on the design of school mathematics curriculum which assumes the everyday mathematical practices to replace by school pedagogical and instructional arithmetic. And this is equivalent to the claim that all formal procedures of school mathematics are applicable to a wide range of real world problems which in turn has a hidden ideological assumption "… that society is ordered along rational lines, founded on objective analyses, and that these same principles form the sole criteria for both individual and social action" (Taylor, 1991:110). Gerdes (1988) also argues that this ideology needs to be changed into the belief that school mathematics and real-world mathematical practices cannot replace one another but rather can supplement each other. A solution to the disjuncture of them can, according to Gerdes, be utilizing indigenous mathematics of weavers, tailors, hut builders, traders, farmers, crafts, etc in the school mathematics curriculum and instruction.

The humanist science and mathematics education, like the constructivists, emphasizes on socialization or enculturation of newly taught ideas/concepts into the students' local, national and global communities rather than into a specific scientific or mathematical discipline (Aikenhead, 2006). According to Smith-Madox (1998), culture-based mathematics education is one such view that puts the influence of personal and cultural knowledge, values and language on learning at the center of science and mathematics education policy and curricula. Culturally relevant mathematics education is a perspective that encourages mathematics curricula, teaching materials and instruction to incorporate students' socio-cultural background and local contexts, as well as their experiential knowledge (Smith-Maddox, 1998). Smith-Maddox (1998) identifies that, depending on the existing political situation of a nation, there are some important issues to be addressed when discussing and developing culturally relevant mathematics education. The first is about the kind of knowledge related to the learners' culture that can be taught in schools which includes identifying cultural practices, incorporating with the academic practices and implementing this integrated material in schools.

The second issue is about how to draw the curriculum and instruction on culturally specific norms that align with national standards. Addressing these basic concerns helps to take care of the students' personal and cultural knowledge not to be in opposition to the school culture and not to be marginalized from the curriculum (Smith-Maddox, 1998; Aikenhead, 2006). This in turn shows that the use of culturally relevant instructional methods changes both the form and contents of teaching and learning since they have to incorporate out-of-school mathematical practices. According to D'Ambrosio (2007b) suggested three strands around which school mathematics curriculum (at least the elementary school mathematics) to be organized. The first one is related to literacy of mathematics including numeracy, reading and interpreting numbers, and computing with numbers. The second strand is called matheracy which is related to mathematical conjecturing, whereas the third called technoracy in relation to the use of technology in mathematics education (D'Ambrosio, 2007b). But how can such organization of curriculum be achieved?

Taylor (1991) identifies four domains through which curricular knowledge is created, processed and disseminated. The first universal domain that is a superset of the other three is the civil society domain. One of the basic issues in this domain is a political issue that directs the curriculum towards social goals in order to serve the majorities such as accountants, engineers, weavers, shoppers, dressmakers, and so on rather than serving the interests of few stakeholders such as business and high level professionals (Taylor, 1991). The second is the academic domain that tries to address the question, how are the out-of-school real world practical activities and thought best codified in to the academic curriculum? The bureaucratic domain is the third domain that represents the executive part of the state that is responsible for all administrative and logistic functions of schooling and materials. It is supposed to address issues such as how the codes of informal knowledge to be embodied in curricular materials (Taylor, 1991). Although this bureaucratic part of the state is required to participate students and teachers as well as society at large, in reality, it is in opposition to this fact because the teacher, students and the society at large are ignored in the curriculum and textbook production process and they are given the responsibility to read and practice everything revealed irrespective of its irrelevance to them locally (Taylor, 1991).

The fourth and last domain is the school domain that should try to answer questions such as: What are the methods most applicable to the passing on of this knowledge to the next generation? According to Taylor (1991), since the classroom is the domain of authority of the teacher, the teacher has the power to influence the knowledge and ideological structure of the students to be reflected in their future real life. The basic assumption of culturally and contextually relevant mathematics curriculum and instruction is that children learn first cultural knowledge such as ways of dressing, talking, communicating, language, counting and so on from their families and the community around them (Boaler, 2002). The relevance aspect of the school mathematics curriculum needs to consider such assumptions and accordingly the textbooks and classroom instructions should increase the relevance of the school mathematics to the learners' lives by providing not only real-world contextualized problems but also real-world solutions to such problems (Boaler, 2002). The central points of relevant mathematics education are, therefore, contextualizing mathematics curriculum, teaching and learning. But what is contextualization?

Contextualizing mathematical concepts is connecting theory and practice by including activities that have meaning in the everyday social and occupational practices, and which are understood and credible to students (Perin, 2011). The following general definition for contextualized teaching and learning is considered throughout this thesis paper.

> Contextual teaching and learning is a conception of teaching and learning that helps teachers relate subject matter content to real world situations; and motivates students to make connections between knowledge and its applications to their lives as family members, citizens, and workers and engage in the hard work that learning requires (Berns & Erickson, 2001; p. 2).

This definition tells that contextualizing mathematical concept or topic taught in the classroom means connecting it with students' out-of-school and real life problems. It includes showing the area where the topic can be applied, how to use it at work, how to use it to solve real life problems encountered in life, and so on (Berns and Erickson, 2001). The aim of contextualization is to help students understand the concept by making it meaningful to them and their everyday life.

Bishop (1988), therefore, suggests that the school mathematics curriculum should be contextualized because “”decontextualized knowledge is literally meaningless’’ (p. 153). In such culture related curriculum and contextualized instruction, the contents, procedures, activities, and problems are developed and organized through ‘bottom-up’ process. In the broader sense that is in the curriculum and syllabus development process, teachers and social groups are at the bottom, and in the narrower sense of at classroom instruction level, students are at the bottom (Rowlands & Carson, 2002). In doing so, it is necessary to consult Aboriginal elders (local people who lived for long period in a given locality) to achieve cultural relevance, sensitivity, validation, and support on the contents and aims of school mathematics curriculum and instruction (Aikenhead, 2006).

Another type of collaboration of policy makers and curriculum developers with the local society is grounding in classroom action research and conducting anthropological studies, as well as organizing deliberative conferences for this purpose (Aikenhead, 2006; MoE, 2002). This is the time when the curriculum can be claimed to address questions such as: relevance to whom: pupils, parents, employers, politicians, or teachers? And relevant to what: everyday life, workplace, further and higher education, students existing ideas? (Aikenhead, 2006). The field of ethnomathematics is there to answer such questions based on ethnographic and anthropological studies of different cultural groups throughout the world (Bishop, 1988). This is discussed in the next section.

2.3. Ethnomathematics

The study of culture in science education is a new research field within the anthropology of education and it views science and mathematics teaching as cultural transmission and learning as cultural acquisition (Aikenhead, 2006). This view is right because in any community there is teaching and learning that transmits indigenous and traditional knowledge to the next generation through cultural practice. But the question is that if it is possible to have teaching and learning as cultural transmissions and acquiring, why do we need schools and other formal educational institutions? D'Ambrosio (2008) provides two main reasons for having schools and other educational institutions: to prepare new generations for citizenship and to enhance creativity. This shows that the existence of formal education is very important and this type of education should aim at preparing competent and creative citizens for the nation to which that educational system serves. Moreover, the formal school education focuses on the aspect of preparing citizenship by providing structured and rigid curricula (D'Ambrosio, 2008). However, still it is possible to argue (at least within the field of mathematics education) that the formal school does not adequately address even the citizenship facet as school teaching and learning practices are complained for their divorce from the learners' sociocultural and political contexts (Bishop, 2008; Knijnik, 2012; Shirely, 2001; Vomvoridi-Ivanovic, 2012). This gap is one of the thematic areas identified by researchers in the field of mathematics education and ethnomathematics is concerned with filling such gaps

One of the reasons for educators to have different positions and views on mathematics is due to the fact that there are varied opinions on the utility of mathematics in life. It is, thus, important for studies and discussions that focus on the cultural aspects of mathematics to begin from explaining the importance and real-world utility of mathematics. Mathematics is a useful tool of everyday life of humans that opens doors to careers and enables informed decisions (Chikodzi & Nyota, 2010). Thus, the application of mathematics is as wide as the extension of human life. Stein (1996) adds more about the usefulness of mathematics in his words, "about two out of every three better-paying jobs require mathematics beyond arithmetic, either as part of the training or for day-to-day use. Only about one out of ten of the low-paying jobs has such a requirement" (p. 3). In general, mathematics is the corner stone of modern civilization (D'Ambrosio, 2006).

Due to this belief of universal utility in every field and all human activities, mathematics is viewed as an absolute truth especially by rationalists (Ernest, 1991). However, contrary to this 'culture-free' view, Bishop (1988) argues that mathematics is a pan-human activity meaning that mathematics is the result of human activities and deals with patterns, problem solving, logical thinking, and so on, with the aim of understanding the world. Studies also revealed that there are cultural bonds of mathematics in different social settings (Bishop, 1988; D'Ambrosio, 1985, 2006; Eglash, 1997). The field of ethnomathematics is one important outcome of such studies and becoming familiar all over the world these days since its introduction by the Brazilian mathematics educator Ubiratan D'Ambrosio in 1985 (Gerdes, 1988a). Thus, one of the factors that laid the foundations for ethnomathematics is that mathematics researcher and educators are aware of the little contribution of non-Western cultures on the currently practiced school mathematics (Naresh, 2008). The raising concern of the mathematics education community on the relationship between mathematics (and hence mathematics education) and culture is the other factor (Carraher and Schliemann, 2002).

Although the term ethnomathematics was introduced by Ubiratan D'Ambrosio in 1985, the interaction of mathematics and culture has been the concern of mathematicians and mathematics educators and researchers throughout the 20th century (Gerdes, 1994; Rosa & Orey, 2011). But what is ethnomathematics about? D'Ambrosio (1985) calls ethnomathematics "the mathematics which is practiced among identifiable cultural groups, such as national-tribal societies, labor groups, children of a certain age bracket, professional classes, and so on" (p. 2). According to this definition, mathematics practiced by any group of two or more people that have similar goals and shared values is ethnomathematics. Later, Ascher and Ascher (1997) went more specific by replacing D'Ambrosio's 'identifiable cultural groups' with 'nonliterate peoples' in their definition of ethnomathematics. But this conception of ethnomathematics as the study of the mathematics of 'nonliterates' has been changed through time because Francois (2010) argues that ethnomathematics is concerned not only with the mathematics of illiterates but any culturally differentiated groups be it literate or illiterate. Skovsmose's (2011) definition of ethnomathematics as the study of mathematical practices of marginalized peoples by replacing the term 'nonliterate' with 'marginalized'. But still the 'marginalized groups' may be marginalized with respect social or economic class, political class, or due to educational opportunity. It seems that all such particularistic conceptions of ethnomathematics are solved since D'Ambrosio (1990) breaks down the term into parts and further defined it in the following way:

> The prefix *ethno* is today accepted as a very broad term that refers to the social cultural context and therefore includes language, jargon, and codes of behavior, myths, and symbols. The derivation of *mathema* is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, inferring, and modeling. The suffix *tics* is derived from techné, and has the same root as technique (p. 81).

This definition views ethnomathematics differently as a technique of explaining and understanding the symbols and objects of mathematics within the socio-cultural context of a given community. So, ethnomathematics is the study of the different forms of mathematics that arise from different groups of people with different modes of thought (D'Ambrosio, 1985).

Related to the above definition of D'Ambrosio (1990) is Barton's (1996) conception of ethnomathematics as a program that investigates the ways in which different cultural groups comprehend, articulate, and apply concepts and practices that can be identified as mathematical practices. However, Barton (1996) suggested that the definition of ethnomathematics is dependent on the culture and belief of the one who tries to define it. So, he suggested that three main dimensions should be considered when defining ethnomathematics. The first dimension is related to temporal aspects that dig out to know when a certain mathematical idea was emerged, history. The second dimension is concerned with cultural aspects of ethnomathematics and the third is mathematical dimension that describes the relationships between concepts and objects within mathematics itself.

To add another but to some extent similar to the above definitions, ethnomathematics is defined as the field of knowledge that studies cultural, social, and political dimensions of mathematics, as well as the informal mathematical knowledge that includes oral practices and mental computations (Knijnik, 2002). One additional concern of ethnomathematics included in this definition is the political dimension of mathematics. D'Ambrosio (2007a) discussed this political dimension of mathematics in terms of social justice and peace. Moreover, D'Ambrosio (2007b) claimed that mathematics education itself has political dimension because asking questions such as 'why we learn and teach mathematics?' lead to critically reflect on the importance of mathematics and objectives of mathematics teaching and learning. Therefore, viewed with the lens of mathematics curriculum and instruction, ethnomathematics presents mathematical concepts of the school curriculum in a way that these concepts are related to the students' cultural and daily experiences, the implicit mathematics in their everyday activities (Vithal and Skovsmose, 1997). This will enhance the students' abilities to elaborate meaningful connections and deepening their understanding of mathematics and its application (Bishop, 1997; Rosa & Orey, 2011). Skovsmose's (1994, 2006, 2012) works discuss in detail the issue of the political dimension of mathematics in terms of democracy and reflective mathematical knowledge. According to Skovsmose (1994), critical mathematics education is meant education that criticizes the real life applicability of the mathematics taught and learnt in school. This is similar to one of the concerns of ethnomathematics to challenge Eurocentric school mathematics as discussed below. The democratic dimension of mathematics education is the right of learners to learn about the mathematical ideas of the local community in which they are members (Skovsmose, 1994).

From the definitions and arguments discussed above, the significance, purpose, and scope of ethnomathematics are just related to the recognition and use of traditional and everyday mathematics of different cultural groups in the school mathematics for academic practices. Rosa & Orey (2011) assert that the mission of the ethnomathematics program is to acknowledge that there are different ways of doing mathematics.

However, despite its young age and its aim of filling the gap between theoretical knowledge of school mathematic and the practical knowledge of real life, ethnomathematics is exposed to critics. The first critic is related to its varied definitions and conceptions by its advocates as shown above (Rowlands and Carson, 2002). This variation again created a debate between mathematics educators on the issue of where should the boundary between ethnomathematics and mathematics lie. The difference between ethnomathematics and mathematics is that mathematics is the practice of the elites and ethnomathematics is the practice of the people (Rowlands and Carson, 2002). Although this claim is not explicitly clarified and hence exposes itself for critics, it tells that ethnomathematics is concerned with the mathematical practices of ordinary and indigenous peoples with unique cultural values and beliefs and mathematics is the practice of mathematicians and schools. However, this kind of distinguishing seems against the vision of ethnomathematics to bridge in and out-of-school mathematical practices (Bishop, 1997; Rosa & Orey, 2011).

Another critics of ethnomathematics is, of course, its principle that school-learning should emphasize on the development of local and practical knowledge of the students (Rowlands and Carson, 2002; Pais, 2011). The concern here is that if students are made to focus only on local and indigenous mathematical knowledge, they will not become competent with other peers in other cultures as global citizens. These and other critics of ethnomathematics could not, however, stop it from its development and improvement. Instead, these critics will strengthen ethnomathematics by informing its limitations and research areas for future improvement. Accordingly, the scope and concerns of ethnomathematics are restructured and reshaped as long as new focus areas arise. The following three subsections describe the forms and concerns of ethnomathematics as a challenge to the conventional western mathematics, as a research field, and as an everyday and workplace mathematical practices of cultural groups.

Ethnomathematics as a challenge to western mathematics

In their discussion of strands of ethnomathematics, Vithal and Skovsmose (1997) argued that ethnomathematics challenges the traditional history of mathematics that relies on European or western cultures. In this discussion, they tried to mention that China, India, Arabs, North Africa, and the Sub-Saharan cultures have developed and contributed to the current history of mathematics. Therefore, it is argued that historically, mathematics has roots in ancient Egypt and Babylonia, and then grew rapidly in ancient Greece and then in the Middle East (Burton, 2007). This and the Indian mathematics of that time were translated into Latin and became the mathematics of western Europe (Ball, 2010) and over a period of several hundred years, it became the mathematics of the world (Joseph, 1987). However, this argument is exclusive of other peoples' contributions. For example, Egypt is mentioned as the only contributor of ancient mathematics from Africa. But other studies and writers argue that many Sub-Saharan Africans also had their own mathematical practices and developments (see for example Gerdes, 2010; Olivastro, 1993; Zaslavsky, 1973). This shows that many different peoples of the world and the interactions between their cultures have contributed to the development of modern mathematics. Thus, the so-called Western mathematics practiced in the academia is originated in the routine everyday practices of small groups and cultures in particular societies all over the world (Naresh, 2008). In spite of this fact, traditionally told histories of mathematics and academic mathematics have disregarded the contributions of non-Western cultures to mathematics (Naresh, 2008; Vithal and Skovsmose, 1997).

Ethnomathematics, thus, emerged as a challenge to the Western mathematics which is practiced by mathematicians and in the academic schools (Moschkovich, 2002; Bishop, 2008; D'Ambrosio, 2006). What challenge does it pose then? It studies historical development of mathematics in different cultural groups and proves that the Western mathematics is among the many (Joseph, 1987). For example, every cultural group has developed its own counting system (Bishop, 1988). Where as the western-oriented mathematics education tries to impose its counting system to other cultures, ethnomathematics challenges this by studying and unfolding the fact that counting systems vary with culture (Baba & Iwasaki, 2001), and hence suggest that mathematics education should be aware of this and that academic mathematics is not universal (Borba, 1990).

Accordingly, it recommends alternative mathematics educational programs and pedagogies to the academic mathematics based on empirical evidence (Bishop, 1990; D'Ambrosio, 1990; Gerdes, 1988a). It suggests ways to contextualize the canonical mathematics practiced in schools to help learners' mathematical understanding and attitude development. It argues that learning with understanding and using mathematical concepts and procedures are culture and context dependent (Bishop, 1988, 1990; Rosa and Orey, 2011). For instance, the traditional or western oriented mathematics education focused on the teaching and learning of formulae and techniques to enable the learners' speed and accuracy of solutions to mathematical problems (Baba and Iwasaki, 2001). Moreover, it advocates the use of problem solving and discussion-oriented pedagogies that do not consider the cultural and background variations among the students even within particular classroom (Sawyer, 2008). Ethnomathematics challenges this conventional practice by studying the means how to make pure mathematics relevant to students of different culture and experience, how to relate mathematics with other school subjects, and how to use school mathematics in out-of-school life (Sawyer, 2008).

According to the western or Euro-centered mathematics education, especially rationalists, mathematics is what the teaching materials and teachers present to students in the classroom (Bishop, 1997). However, studies reveal that there are various mathematical knowledge and practices outside school and everyday life situations of the learners. And thus, "teachers must emphasize the importance of building upon the students' foundational knowledge in a way that brings in their culture and their history in order to promote value in these cultures" (Harding-

DeKam, 2007: 1). This shows that classroom mathematics and out-of-school mathematics have to go in match in order the learners to appreciate academic mathematics. Ethnomathematics, therefore, tries to fill the gap between in- and out-of-school mathematics through research (Moschkovich, 2002).

Ethnomathematics as a research field

Viewing ethnomathematics as a research field, Bishop (1997) identified three focus areas. The first area is concerned with the mathematics in the traditional practices of different cultural groups or societies. This includes the indigenous mathematical activities such as counting systems, arithmetic and number operations (adding, subtracting etc), house building, games, sports, number systems, gestures and symbolism, games and puzzles, geometry, space, shape, pattern, symmetry, art and architecture, time, money, networks, graphs or sand drawings, artifacts (Vithal and Skovsmose, 1997).

The second dimension is geared towards studying the different histories and philosophies of mathematics with implications to education and pedagogy (Barton, 1998; Francois & Kerkhove, 2010). This examines and uncovers the historical contributions of different peoples and cultures all over the world such as Africans, Arabs, Indians, Chinese, Latinos, and so on to the development of the modern mathematics what Bishop (1988) calls 'western mathematics' which is practiced in schools and other educational institutions. Barton (1998) explains the need for philosophical dimension of ethnomathematics as, "It is not enough just to say that mathematics is culturally determined and to go on acting as if this is the case simply because we believe it to be so. We must convince others particularly mathematicians" (p. 54). This shows that ethnomathematics has, besides its concern on research in mathematics and mathematics education, philosophical dimension.

The third area of focus is studying the children's outside school mathematical knowledge. This is aimed towards understanding how students succeed in school mathematics more when it is connected with their everyday mathematics. Studies regarding the students' out-of-school mathematical knowledge revealed that arithmetic operations and proportional relations (Carraher & Schliemann, 2002), measurement related concepts and techniques (Adams & Harrell, 2010), geometry (Millroy, 1992; Zaslavsky, 1973), and other mathematical practices are used in everyday and out-of-school settings by children. Other ethnomathematical studies also showed that connecting these out of school mathematical experiences of learners facilitates a successful learning in academic mathematics (Boaler, 1993; Ezeife, 2003; Sawyer, 2008; Wager, 2012).

Ethnomathematics as everyday and workplace mathematics

Everyday mathematics is one of the concerns of ethnomathematical studies (Bishop, 1997; Orey and Rosa, 2011). Everyday mathematics is the mathematics used in the ordinary cycle of life activities of the indigenous peoples (Lave, 1988). It is the mathematical knowledge of ironworkers, weavers, tailors and other practitioners as they undertake their various crafts and professions (Barton, 2004). It is specifically connected to the mathematics used by people in everyday settings and the research done in out-of-school situations which has investigated the thinking and practices of participants in situations where they developed mathematical knowledge in a socio-cultural context (Saxe, 1991). In trying to differentiate it from academic mathematics, Moschkovich (2002) describes everyday mathematics as:

> Academic mathematics will refer to the practices of academic mathematicians; school mathematics will refer to the practices of students and teachers in school; everyday mathematics will refer to the mathematical practices that adults or children engage in, other than school or academic mathematics; and workplace mathematics, a subset of everyday practices, will refer to the

> practices of adults or children in workplaces other than schools or academic mathematics (p. 2).

Moschkovich addresses that everyday mathematics is the mathematics practiced in the continuous and routine life activities of all members of the society to fulfill the individual and social needs important for their survival. It is the mathematics performed in market, interest calculation, saving, loss, profit, building, farming, weaving and so on. It is mathematical practice in any situation but outside school setting. Bishop (1997) also summarized such everyday mathematical experiences as follows:

> There are more than 2000 different counting systems in Papua New Guinea and Oceania, some use a 5 cycle method, some a 2 cycle. There are many body-counting systems (extensions of finger counting) where the number name is the name of the part of the body being pointed to; there are many different ways to add, subtract, multiply and divide (and still get the right answer!); there are different ways to find the areas of rectangles. One method used by farmers in Brazil to find the areas of their fields is to find the average lengths of the opposite sides and multiply the averages together; there are many different games, puzzles, sports and dances which have mathematical connections; carpenters, navigators, fishermen, and tailors all have their different mathematical knowledge and skills (p. 3).

Bishop is providing the everyday mathematical practice in relation to the different branches of mathematics such as counting, arithmetic, geometry, measurement, and so on observed in different workplaces, games and plays of different people and cultures. Bishop (1988) categorized these everyday mathematical practices of any cultural group into six areas. They are: counting, locating, measurement, design, play and explaining. If so, what is the difference between everyday and workplace mathematics and between everyday and school or academic mathematics? This is a relevant question that will be addressed in the paragraphs that follow.

According to Arcavi (2002), everyday mathematics refers to the mathematics learning and practices that take place outside school or academic setting. Workplace mathematics is a subset of everyday mathematics practiced by adults or children in the workplace, other than school or academic setting (Moschkovich, 2002). From this, it is safe to conclude that everyday mathematics is broader than workplace mathematics because it includes everything done in the routine everyday activities such as the home, play or games, social gatherings, recreational activities, in the preparation for work, and so on. School mathematics is the mathematics practiced in schools by teachers and students guided by a structured curriculum and well organized teaching/learning materials (Moschkovich, 2002). According to Moschkovich, academic mathematics is the mathematics carried out by mathematicians with the aim of conjecturing new concepts or procedures, proving theorems of own or that of others, discourses on mathematical theories and assertions. Discussing the difference and similarities of these concepts is, however, beyond the scope of this study. But the focus here is the mathematics in workplaces and game/plays and the issue of how to connect this with the classroom mathematics. The following section offers illustrative examples of previous related studies and their empirical results on this issue.

2.4. Illustrations from Previous Research

According to Herron and Barta (2009), although there is limited research on the relationship of mathematics education and culture, these few studies have been attracting the community of mathematics educators towards this issue. Research in the previous few decades has, therefore, indicated a growing interest in examining and understanding the mathematical practices in distinct cultures (e.g. Bishop, 1988, 1997, 2012: Gerdes, 1988b, 1999, 2010) and everyday situations within a given culture (e.g. Masingila, 1994) to use findings in school mathematical practices. These investigations mainly focused on everyday mathematics such as workplace mathematics, students' out-of-school mathematical practices, and on the issue of how to integrate in- and out-of-school mathematical ideas and practices (Bishop, 2008; Masingila, 1994; Moschkovich, 2002; Rosa and Orey, 2010; Zhang and Zhang, 2010). It is, therefore, worth mentioning and describing some illustrative examples on this issue.

Research conducted in workplaces is one dimension of the research field of everyday cognition. It is believed by mathematics educators and employers in several countries that the students' school experiences should ensure that they are well prepared for work (Aikenhead, 2006). Thus investigations into the practitioners' practices i.e. workplace related researches are necessary to uncover the implicit mathematical ideas and practices embedded in their work-related activities and to connect them with school mathematics. Workplace research mainly focuses on examining and mapping out the mathematics needed for the workplace. It is a means for critical observation and description of the mathematical knowledge of the workers in workplaces (Saxe, 1991; Moschkovich, 2002). Although the research on workplace mathematics is in its young age, it is possible to provide some examples of empirical research studies conducted on it.

The first of these studies was carried out by Smith III (2002) in the U.S. automobile manufacturing industry under the project "Mathematics in Michigan's Industrial Workplaces". The aim of the study was to examine the everyday mathematics in the automobile manufacturing work and mathematical activities that are familiar, repeated, documented, and supported by material and social structures. The study focused on the mathematical reasoning such as spatial and geometrical reasoning, numerical reasoning and measurement related thinking of the automobile production workers. In visiting 16 related workplaces, the main research method was direct observation and documentation of workers' actions, as well as interviewing workers and collecting artifacts such as copying workers' written worksheets. The findings of this study are presented in four categories by the researcher. The first was a methodological finding that it is impossible to see mathematical content of work activities from an independent, objective, and universal standpoint because seeing mathematics in work activities involves experience with different workplaces and careful analysis and interpretation from an explicit point of view. This shows that it is difficult to see the type of mathematics being done and to locate where it is being done even within a specific and narrow workplace without the necessary experience. The second finding was that the numerals that appeared in work activities were closely related to the quantities attached to the objects produced, and computations with those numerals were supported by handheld calculators, artifacts.

The third finding is that the organizational structure and management of workplaces directly influenced the level of mathematics expected of production workers, either increasing or decreasing it. That some jobs required a surprisingly high level of spatial and geometric competence, which outstripped the preparation that most K-12 curricula provide, was the fourth finding. The researcher concluded that

> numbers are almost embedded in quantitative contexts that provide meaning for computation…..the challenge of making school mathematics responsive to the needs of the non-college-bound is to identify the most powerful set of core competencies that can serve as a foundation for work (Smith III, 2002:129).

Other studies conducted on workplace mathematics of different cultural groups in different countries include Rosin's (1984) anthropological study of the arithmetic calculations performed by an illiterate Indian in his workplace of making gold medallions; Millroy's (1992) ethnographic investigation of a group of carpenters in Cape Town, South Africa; Masingila's (1994) ethnographic study of the mathematics practice in carpet Laying workplace in the United States; Naresh's (2008) case study of workplace mathematics of the bus conductors in Chanai, India; and workplace mathematics of the Mozambican farmers' house construction by Zhang and Zhang (2010).

The next example is research on the mathematics performed by students in their out-of-school activities. There are empirical research findings on students' out-of-school mathematical practices including mental computations and quantitative reasoning. Carraher and Schliemann (2002) support this argument by saying, "research on everyday mathematics has repeatedly produced evidence that people learn mathematics outside school settings. For example, it is researched young children discover the commutative nature of addition even before entering schools" (p. 133). The following is an example of a research on children's out-of-school mathematical experiences. The author of the article considered in the example starts the discussion by comparing and contrasting mathematics learning in and outside school as follows:

> In school, children typically work alone, without tools, and are expected to acquire and apply general rules to problems often removed from any meaningful context. In contrast, learning and reasoning outside of school are often guided by others, embedded in meaningful activities, and use knowledge linked to the problem situation, such as the objects being considered, the participants' goals, and the available cultural artifacts (Guberman, 1996; p. 1609).

Guberman (1996) studied the arithmetical activities and achievements of children of Recife, a city in Brazil. The study focused on children's transactional activities performed when their parents send them to local stands to purchase goods. The project employed of 105 of children of between 4-14 years old and their parents. The socio-cultural context the study considered was that parents give responsibilities to their children such as transactional activities and that the children participated in the study had little instruction in school mathematics but regularly encountered arithmetic problems as they purchased items at local stands.

Guberman (1996) used different methods of data collection and analysis based on a framework that emphasizes cultural contexts. As part of the procedures, parents were interviewed at their homes, currency identification screening protocol was administered to children, those children who identified the currency notes correctly were asked to do arithmetical problems, and finally interviews were taped and transcribed. The researcher found that: (1) Most children did the tasks using their informal methods even in activities distal from direct verbal observations with parents; (2) currency strategies of solving problems provide further evidence of the shift from manipulating external aides to manipulating internal representations of quantity because "From 6 to 14 years of age, children were more accurate using currency although they used it less frequently, an indication that they were developing strategies that are less dependent on the concrete presence of the currency." (Guberman, 1996; p. 1621); and (3) cultural artifacts are effective external aides in problem solving during an intermediate stage of skill acquisition. Guberman concluded that parents influence their children's development through the activities and settings they make available to children in addition to their immediate interaction with their children. This shows that by adjusting the mathematical complexity of children's commercial transaction, parents "provide a supportive environment for children to practice and extend their mathematical skills and understanding." (Guberman, 1996; p. 1622).

Other studies of this kind include: Posner's (1982) experimental investigation of the development of mathematical concepts among children from two groups of West African (agricultural and merchant) societies and found that children used counting procedures to solve problems such as addition and determining precise numerical representations though schooled children did correct counting and calculation than unschooled ones; and Masingila's (2002) examination of middle school students' perception of mathematics and how they use it outside the classroom using interviews and log sheets and found that students' perceptions of their out-of-school mathematics practices were strongly influenced by their view of mathematics.

The third issue that needs illustration using previous research findings is that of the interaction between ethnomathematics and mathematics education or more specifically the interplay of out-of-school mathematical practices and ideas with the school mathematics. Studies on the influence of out-of-school mathematical ideas on school mathematical practices also showed that the low enrolment and poor performance in mathematics classes and examinations of students from indigenous people is due to cultural difference between the school environment and their original environment (Ezeife, 2003). This divorse between the mathematics in the actual practice and that of school mathematics caused misconception of mathematics as nonutility in the real life (Chikodzi & Nyota, 2010). This is why, in traditional classrooms, the teacher acts as an expert who instructs and explains to students how to solve problems while his/her problems seldom connect to children's real-life situations and hence are not always meaningful to the students. Despite the evident discontinuity between school mathematics and out-of-school practices some authors have observed interplay between them.

Bishop (2008), points out that different cultural groups emphasize different theories of knowledge and should be considered by the mathematics instruction. Zaslavsky (1994) also suggests that mathematics teaching and learning should lie on the ground of meaningful context that considers the students' experience and culture. It is because ethnomathematics is a powerful means to validate students' lived experiences by studying and integrating the mathematics used in their culture which helps the children to learn that their ancestors contributed to the development of important mathematical ideas which in turn helps to develop positive attitudes towards mathematics (Kitchen & Becker, 1998). Masingila (1993) adds that 'Teachers should build upon the mathematical knowledge that students' bring to school from their out-of-school situations' (pp. 19-20). Besides these recommendations, Saxe (1991) found evidence that school mathematics and the mathematics of street children's candy selling practice in Brazil affect each other.

A number of such research studies that have been conducted in both out-of-school everyday mathematical practices and classroom settings suggested educational experts and teachers to integrate academic and everyday mathematics in classrooms to improve students' academic achievement (Arcavi, 2002; Saxe, 2002). This helped curriculum and instruction experts of many nations to go beyond just passively reporting the importance of everyday practices of different cultural groups in education by contextualizing their educational activities (Presmeg, 2007). The question becomes then how to make these research findings practical in schools. How can we use this research to bridge the gap that exists between everyday and academic/school mathematics? Research studies in recent years have attempted to focus on such questions and find ways to bring components of everyday mathematical practices into the classrooms. Two empirical illustrations that can be described here are the work of Brenner (1985) in K-4 schools in Liberia and Civil's (2002) investigation of fifth graders in United States of America.

Brenner (1985) studied four (two urban and two rural) Liberian schools focusing on pre-school, grade one and grade four students' methods of solving arithmetic problems of whole numbers aiming to demonstrate that a contextually based study of arithmetic practice gives new insight as to how children actually accomplish some mastery of the school curriculum. The researcher administered arithmetic mathematics test together with interviews to collect data and examined the tests to determine the methods that the students used in solving the arithmetic problems by seeing their written methods and the errors they made. The finding of this study showed that the solving methods used by students were similar to the methods used by illiterate people in the out-of-school settings such as markets and other workplaces and she concluded that "cognitive practice must be examined as part of its functioning context, including analysis of teacher-student interaction and the evolving relations between lesson content and the learning processes negotiated by the participants." (Brenner, 1985, p.185).

Civil's (2002) study of grade five students in a bilingual school of USA is the second example, which was conducted under a larger project called 'Funds of knowledge for teaching' with a primary goal of "developing teaching innovations built on the background, knowledge, and experiences of students, their families, and their communities" (p. 45). To this end, the classroom teacher, the assistant researcher and the researcher herself prepared for the classroom and came with a shared goal of developing such an innovative teaching methodology that combines school mathematics and mathematicians' mathematics while at the same time building on the students' out-of-school mathematics. The data obtained from observations, debriefing meetings, field notes, interviews with teachers and students, as well as artifacts were analyzed. The findings of this study also revealed that students participated in classroom activities when the task was related to everyday and out-of-school mathematical practices but they withdrew from the classroom activities when the discussion moved to more formal school mathematics.

Other studies related to this issue include: Ezeife's (2002) investigation of undergraduate pre-service teacher students in Canada and concluded that integrating the learners' culture and environmental contexts into mathematics instruction has a positive effect; Wager's (2012) investigation of 17 teachers' participating in a professional development seminar sessions on the importance and methods of incorporating children's out-of-school mathematical practices using interview and observation methods and identified four methods of how to integrate them viz. using student experiences as context for problems, linking these experiences to school mathematics, identifying embedded mathematical practices prominent in these experiences, and teacher initiated situated settings to use the classroom as a site of culture.

There is also research evidence on the influence of school learned mathematics in successful accomplishment of out-of-school and workplace activities (eg. Naresh, 2008). For example, Saxe (1991) argues that school learned mathematics affects the everyday mathematical practices in real life workplaces by saying, "The school child makes use of a specialized knowledge of number orthography as a central feature of mathematical problem solving, whereas the unschooled child does not, relying instead on specialized knowledge of numerical representations linked to the currency system." (p. 151). The illustrating examples provided in this section inform about the status of ethnomathematical studies worldwide. What about the status of ethnomathematics in Africa particularly? Are there more studies concerning the indigenous knowledge practices of mathematics conducted in African cultures? These questions will be addressed briefly in the following section.

2.5. The Status of Ethnomathematics in Africa

In the previous section, the historical development and conception of ethnomathematics is reviewed and described in its universal context. This section briefs the status of ethnomathematics in Africa. Traditional mathematical ideas and practices of African peoples, which are related to the ethnomathematics program of D'Ambrosio (1985), have been attracting since the 1970s (Gerdes, 1984, 1985, 1988a,b; Zaslavsky, 1973). The first of its kind that surveyed and documented African traditional mathematics is Zaslavsky's (1973) book of "Africa Counts: Number and Pattern in African Culture". This book presents the history of mathematics in Africa as well as traditional or indigenous mathematical practices of different African cultures. Among the mathematical concepts identified from the survey of African cultural groups within the region of South of Sahara and presented in this book include: numbers including words and gestures; number systems and counting systems; time and money; and measurement and geometry (Zaslavsky, 1973).

With respect to specific cultural tribes, Zaslavsky's (1973) survey focused on Maasai people of Kenya and Arusha people of Tanzania from Eastern region of Africa and Yoruba people of Nigeria from the Southwestern Africa. Although there are similarities among many African countries and cultures, it is therefore difficult to claim that the results of this survey are enough to conclude the mathematical practices are representative of all African traditional mathematics. However, there is no doubt that this survey initiated many African and non African researchers to study African mathematics. Gerdes' (1984) study of the mathematics Olympiad in Mozambique of Southern Africa is one example although the very nature of such Olympiads is not directly related to ethnomathematics but creating competition among students of in school mathematics. Gerdes (1985) also studied how ancient Egyptians used different methods and formulas to find the area of a circle. Olivastro's (1993) book entitled 'Ancient Puzzles: Classic Brainteasers and other Timeless Mathematical Games of the Last Ten Centuries' contains Elements of African mathematical practices and ideas in traditional games. These traditional mathematical concepts such as the case of multiplication methods used by ancient Ethiopians (See section 1.1 of this paper) are similar to the current binary system of computers.

If we try to review and analyze the mathematical concepts and procedures studied in different African cultures, there are many such studies since the beginning of the history of ethnomathematics in the 1980s. Few examples of such studies include Lave's (1988) writing that presents the arithmetic practices of Liberian Tailors, Gerdes' (1988b) investigation of geometrical concepts in Mozambican peasants, Millroy's (1992) ethnographic study of carpenters in South Africa, Olivastro's (1993) investigation of Ethiopian priests' multiplication methods, and Jama's (1999) investigation of traditional mathematical practices of the Somali people in the Horn of Africa.

However, still there is scarcity of studies and publications on African traditional mathematics. In addition to this scarcity, even the exiting literature is skewed to some part of the continent (especially to the Western and Southern parts). But, given all these gaps, there is an increasing motivation of the educators and researchers of mathematics education to study the indigenous mathematical knowledge and practices of the peoples in the continent in relation to school curricula and instruction. There are some reasons for such increased attentions towards researching the indigenous mathematical knowledge and practices as well as the interplay between in and out-of-school mathematical practices of African students. According to Gerdes (2002) such attention arose as a response to the negative attitude of school students towards mathematics perceiving it as colonizers' obstacle placed in school to hinder the progress of African students.

One example of such empirical studies is Gerdes' (1988a) study of the mathematical aspects in the 'sona' sand drawing tradition of the Tchokwe people of Angola. From these traditional drawing practices, Gerdes (1988a, 1990) identified different geometrical shapes (such as symmetries and geometrical models to compute prime numbers and greatest common divisors) and construction rules which have educational implications such as appreciation of own knowledge and creativity. Another example is Achor et al.'s (2009) experimental study aimed to understand the effect of ethnomathematical teaching approaches on the achievement of Nigerian student. Still other studies include Nkopodi and Mosimege's (2009) investigation of the morabaraba game in South African and Chikodzi and Nyota's (2010) study of mathematical ideas in traditional games of the Shona people of Zimbabwe as well as the implications of these practices to classroom mathematics instruction. All these examples researched the existence of mathematical ideas and procedures in traditional practices of African peoples as well as their possible use in school mathematics curriculum and instruction. One additional example of such studies is Mogari's (2004) study that examined the development of geometrical concepts by South African children.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

> The procedures of qualitative research, or its methodology, are characterized as inductive, emerging, and shaped by the researcher's experience in collecting and analyzing the data. The logic that the qualitative researcher follows is inductive, from the ground up, rather than handed down entirely from a theory or from the perspectives of the inquirer. Sometimes research questions change in the middle of the study to reflect better the type of questions needed to understand the research problem. In response, data collection strategy, planned before the study, needs to be modified to accompany the new questions (Creswell, 2007; p. 19)

This chapter deals with the points raised by Creswell (2007) above. It shows how the study was conducted following flexible methods and strategies. The chapter is, therefore, organized into six sections. The first section describes the paradigm which guided the study, the design, and research methodology including reasons why the current method was chosen and how it helped to understand the situation on the selected phenomenon. The second section is about entry to research sites and participants. The third section deals with data collection techniques and procedures. The fourth section discusses the data analysis methods and procedures. The fifth section presents the methods of validating the qualitative data used and the sixth section briefs ethical considerations of this study.

3.1. Paradigm, Methodology and Design of the Research

Any type of research is guided by three major assumptions and principles: paradigm related assumptions that deal with general beliefs about the issue; design related principles; and methodological issues. This section discusses these three assumptions in relation to their importance in the current study.

3.1.1. The Research Paradigm

A paradigm is a set of beliefs, principles, assumptions, and laws to guide action (Creswell, 2007; Hatch, 2002; Willis, 2007). The assumptions in a paradigm include general ontological, epistemological, axiological, rhetorical, and methodological assumptions (Creswell, 2007). Ontology refers to the philosophy of reality including its nature and existence, where as epistemology deals with the knowledge about the reality and the relationship between the knower and the reality to be known (Hatch, 2002). Methodological assumption, on the other hand, concerns about how the knower comes to know the reality i.e. the particular ways and practices used to achieve knowledge about the reality (Willig, 2008). Whereas axiology is related to the role of values in a research, rhetorical assumptions deal with the language of research (Creswell, 2007). With regard to these five assumptions, different paradigms take different positions.

The two realist paradigms, positivism or empiricism and post-positivism or post-empiricism, assume that reality exists out there independent of individual mind and social interactions. So, knowledge is discovered through scientific methods such as experiments and statistical inferences to produce predictions (Hatch, 2002; Willig, 2007). Moreover, their axiological assumption is that any scientific research should be free of the researcher's values. However, the idealist paradigms such as interpretivism and constructivism argue that there is no naturally existing objective reality but individually and socially constructed multiple realities with socially shared meanings and understandings (Creswell, 2007; Hatch, 2002; Willig, 2008). According to Willis (2007), interpretivism rejects the positivists' claim that the same research methodology (quantitative) can be used to study human behavior as is used in the science fields such as chemistry or biology to study controlled chemical reaction experiments. These interpretivists reject the claim that every field of study should use experimental quantitative methods. This is because the researcher as a human being has some intrinsic values and feelings and should reflect how his/her values influenced the study's data and findings. This reflection of the researcher is again helpful to present the different meanings of different participants.

Thus, for interpretive researchers, "what the world means to the person or group being studied is critically important to good research in the social sciences….and qualitative methods such as case studies, interviews, and observation are better ways of getting at how humans interpret the world around them" (Willis, 2007; p. 6). An interpretivist researcher seeks to explore and understand the human and social situations, as well as uncover the meanings, understandings and interpretations of the persons involved in the study within their natural setting (Hatch, 2002). This study is, therefore, guided by the interpretivist paradigm which is similar to the sociocultural theory.

3.1.2. The Research Methodology

Methodology is a theory and analysis of how research should proceed, while methods are techniques for gathering evidence (Dane, 1990). Choosing a particular type of methodology and design in a study depends on the study's governing research questions and the findings intended to get from these questions (Merriam, 1988). There are three widely used methodologies in the literature, quantitative, qualitative and mixed methodologies (Hesse-Biber, 2010). Quantitative methodologies are guided by positivist and post-positivist paradigms while qualitative methodology is influenced by interpretivist or constructivist philosophy (Hatch, 2002; Merriam, 1988; Willis, 2007). Mixed methodology is influenced by both positivists and interpretivists and hence it employs methods of both quantitative and qualitative methodologies (Hasse-Biber, 2010). In quantitative studies such as experiments and surveys, the focus is how to determine quantities with variables controlled in order to test a particular predetermined hypothesis. Most of the time, the findings of a quantitative research are end products of cause-and-effect whereas the findings of a qualitative study are intensive descriptions and interpretations of a phenomenon (Merriam, 1988).

The current study was neither concerned with testing pre-set hypothesis nor concerned with experimental interventions of teaching in the classroom. Rather, it was intended to understand the mathematical practices in different workplaces and games of the target people in relation to the mathematical practices in schools. There are many reasons why research questions in qualitative research cannot replace hypotheses in quantitative study. Research questions in a qualitative study can be flexibly amended and changed many times while the study is going on, but hypotheses in a quantitative study have only two alternatives to be chosen at the end of the study based on statistical data (Creswell, 2007). According to Willis (2007)

> Research questions are different from hypotheses. A hypothesis is a claim, derived from existing theory, which can be tested against empirical evidence. It can be either rejected or retained. A research question, by contrast, is open-ended. That is, it cannot be answered with a simple ‘yes’ or ‘no’. A research question calls for an answer that provides detailed descriptions and, where possible, also explanations of a phenomenon (p. 20).

This shows that research questions in a qualitative study are nondirectional and not rigid but proposed at the beginning for the researcher not to miss the focus of study.

Quantitative study could not adequately address the current problem raised because it overemphasizes on assumptions such as physical environment or context influences human perception than mental influences. Furthermore, as it employs structured and rigid procedures and instruments, it does not allow flexible improvement of steps and questions according the situation or context (Devers and Frankel, 2000; Hatch, 2002; Willig, 2008; Willis, 2007). Moreover, quantitative surveys that use prescribed variables may not capture the complex cultural practices of mathematics in the everyday activities of the target population here because variables of the current study were expected to emerge in the process. It is important to note here that the purpose of including the scope of the study in a qualitative study is not to specify the variables of the study but to delimit or show the boundaries and contexts of the cases of the study (Yin, 2003).

One of the interpretivist assumptions, according to Creswell (2007), is investigation of participants in their natural setting with the researcher being one type of data collection instrument. A second assumption is employing inductive data analysis and emphasis on participants' meanings on the studied issue or phenomenon. Another assumption is related to viewing the data and findings through the lens of the socio-cultural context. Therefore, the intension of this study was to observe the participants in their natural setting of the respective selected workplaces and interpret their sayings and activities following emergent methods.

A qualitative researcher should also assume that there are multiple realities from multiple participants and need to interpret the meanings based on the lens of socio-cultural, political, historical, and contextual perspectives. (Creswell, 2007; Hatch, 2002). Moreover, a qualitative study accounts for a holistic approach in a sense of sketching the larger picture that emerge in the course of the study by identifying the factors that influenced the process and the interactions between these factors beyond the cause-and-effect pattern (Creswell, 2007). Thus, a qualitative methodology was used to understand the problem investigated here. This is because through naturalistic and in-depth inquiry of both out-of-school workplace and school classroom practices, it was possible to obtain rich information and discover new ideas and practices in relation to mathematics and mathematics education (Creswell, 2007).

However, still there are many types of qualitative methodologies, in the words of Hatch (2002), “It could be said that there are as many kinds of qualitative research as there are qualitative researchers” (p. 20). Among these, case study, ethnography, grounded theory, narrative research, and phenomenology are commonly mentioned and used (Creswell, 2007). Ethnographic study requires participant observation of the full range of social behavior (Scott & Morrison, 2006) whereas the current study employed observation of only workplaces in relation to mathematics. A narrative study is another type of qualitative research that focuses on a biography of a person recorded by the researcher, autobiographies of individuals recorded by themselves, personal life history, personal experience stories, or on oral histories given by individuals about an event (Creswell, 2007). Since it is related to chronological description of events or story of an individual, it was not suitable to the current study that intended understanding of many participants' current mathematical use in their activities.

Phenomenological studies focus on describing what many participants have in common as they experience a given phenomenon with the purpose of reducing individual experiences on the phenomenon to a description of a universal essence and very nature of the phenomenon without any reflexive addition of the researcher's experiences (Creswell, 2007). As the role of the researcher was important part of the process in the present study, phenomenology was not used as a methodology. Grounded theory is another qualitative approach that goes beyond the thematic description and narration of the respondents' experiences, generate a general explanation or discover a theory to guide application of findings and further research (Hatch, 2002, Creswell, 2007). The ultimate goal of this study was not to develop a theory, but rather to understand the issue investigated from the view points of respondents and if the understanding occurred leads the researcher to put the findings into an organized theory, it is well and good. Moreover, according to Creswell (2007), grounded theory is used when there is no any theory or there is incomplete theory related to the investigated issue, but the related literature (see chapter 2) provides different theories and theoretical models in the field currently studied.

Another criterion for selecting a particular research method is the research questions of the study intended (Yin, 2003). The above discussed methods are suitable when the research questions are 'what' and other types, other than 'how' and 'why' questions that the current study asked. Due to the above reasons and shortcomings of other qualitative strategies, none of them was used in this study. Case study was, therefore, chosen as the suitable strategy to address the research questions of this study for reasons discussed below. A case study is an empirical qualitative inquiry that studies a timely phenomenon within its natural/undisturbed context and is used when the boundaries between the studied phenomenon and its context are not known (Yin, 2003). Arguing that there are quantitative as well as qualitative case studies, Merriam (1988) characterizes qualitative case study as particularistic, descriptive, heuristic, and inductive that focus on contemporary issues. According to Creswell (2007), a case study is:

> a qualitative approach in which the investigator explores a bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information (e.g. observations, interviews, audiovisual material, and documents and reports), and reports a case description and case based themes (p. 73).

The definition given by Creswell includes the types of case study designs and data collection methods and procedures, as well as the outcomes of a case study. All the above definitions agree that a case study is suitable to use when the variables of the study are not controlled and the limits of the contemporary issue under investigation are not clear. Therefore, a case study was chosen as a methodology for this study because the research questions were exploratory type 'what' questions and explanatory type 'how' and 'why' questions which focused on the current process and practices (Yin, 2003) of mathematics in the Khimra people rather than outcomes. Processes are live goings-on in which the doers are observed doing the activity whereas outcomes are end products of processes and procedures of activities with specific goals (Uys & Gwele, 2005) which do not necessarily show the doer, the procedures followed and the rationale behind them. Moreover, as intended in this study, a case study is suitable if the researcher plans to have a minimum control over events (Solomon, 2008), focus on the context instead of relying on specific variables, is geared towards discovery, aims to explore and describe the issue studied (Gerring, 2007; Merriam, 1988; Yin, 2003).

Yet, even within the qualitative case study, there are three types of case studies viz. intrinsic, instrumental and multiple case studies (Creswell, 2007; Stake, 1995; Yin, 2003), of which a researcher should make a choice. Whereas intrinsic case study focuses on the learning and understanding about individual case itself rather than using it to learn about another issue, instrumental case study uses individual case(s) as instrument to know about something else which is not related to the case (Stake, 1995). Multiple or collective case study employs multiple instrumental cases to study about an issue or phenomenon (Stake, 1995; Yin, 2003). The following subsection discusses the choice of the research design for the current study based on the differences of the three case study designs given above.

3.1.3. Research Design

A methodological or research design is a general and holistic plan that includes the ways of sampling, methods and instruments of data collection and data analysis

(O'Leary, 2004). The choice of a design in studies, such as this, depends on three main criteria: the study problem, the question it forwards, and the intended outcomes (Merriam, 1988). A multiple or collective case study design was used in the current study in order to address all the research questions by collecting and analyzing data from replicating cases. According to Yin (2003), two or more cases are called replicating cases if the findings of each case supports the same theoretical proposition-an assertion of a theoretical issue in order to inform the researcher how and where to find relevant evidence. For example, the propositions of this study are the purposes (Yin, 2003) stated in chapter one. So, if the three cases defined in this section bring results that support the themes that address these purposes, they are replicating cases. Similarly, if the results of the three cases resemble the theoretical propositions reviewed in chapter two, still they are replicating cases.

A multiple case study design was suitable to use in this study because the evidence obtained from multiple cases was more compelling for the overall study to be regarded as more robust (Gerring, 2007; Yin, 2003). This means that, using multiple cases, it was possible to "examine how everyday mathematics is performed in different environments and the design of the study can incorporate a diversity of contexts" (Stake, 2006; p. 23) where the environments in the context of the current study are workplaces and schools.

Yin (2003) identifies two types of multiple case study designs, holistic and embedded. The holistic multiple case study design consists of multiple cases with each case only a single unit of analysis and that of an embedded multiple case study design includes multiple cases with each case having multiple units of analysis embedded within (Yin, 2003). Therefore, a multiple case study (embedded) design was used in the current study because there are embedded cases or units of analysis within each case selected as described in the next paragraph.

With regard to deciding the number of cases to be included in a multiple case study design, Stake (2006) suggests that rather than sampling cases based on attributes, it is better to emphasizes on the balance and variety of cases. That is what happened in the present study because the variety of workplaces is considered instead of randomly selecting representative sample of one workplace from the site, Wag Khimra zone. As to the criteria of selecting cases and units of analysis, both Yin (2003) and Stake (2006) agree that there should be clear criteria and justification for selecting a case or unit of analysis. For instance, Stake (2006) proposed three general criteria to be addressed in selecting a case: the relevance of the case to the quintain (the topic of investigation); whether the case selected provides any diversity across contexts; and whether the case provides a good opportunity to learn about the complexity and contexts. Yin (2003) also suggested that every case should serve the objectives and research questions of the study, each case should have two or more units of analysis, individual persons can be units of analysis, and each case should have contextual boundaries from one another. Therefore, the cases in a multiple case study can be places, persons, or events to observe (Stake, 2006), workplaces (Naresh, 2008), and schools (Solomon, 2008; Yin, 2003).

Therefore, three cases were included in this study. The first case is a category containing eight workplaces (weaving, farming, house construction, traditional brewing, shop, shoeshine, pottery making, and sewing craft) and two games (tirga and geveta). In this case, the intention was to understand the mathematical practices in different workplaces (units of analysis). Part of the context of this case study is the culture and traditional values as well as the interactions of the Khimra people. The second and third cases are two schools from different districts (weredas) with units of analysis being teachers and students. In these two schools (cases), the awareness and use of everyday or out-of-school mathematics in the classroom was examined within the contexts of school situation and from the experiences of both teachers and students. In the two school related cases, the following questions were addressed. To what extent do textbooks make use of real life related mathematical ideas, activities, and examples in presenting the content? How do teachers and students perceive everyday mathematics and to what extent do they use it in their classroom practices?

According to Yin (2003), it is possible for a case study researcher to choose only one or two cases but in order to increase the degree of or deep understanding, it is recommended to use three or more cases. Since the purpose of the current study was related to understanding the issue raised, three cases were selected. This means that on one hand, if one case of workplaces/games were chosen, it would be difficult to understand about the school implication of the mathematics practiced in the workplaces/games. On the other hand, if schools were chosen to be the cases of the study, it would be difficult to understand the out-of-school mathematical practices as the topic implies. This shows that taking cases form both out-of-school settings and that of schools is necessary to address the research questions and the problem rose. Now, what things need clarity is that of the context and boundaries of each case. The difference in context and boundary between workplaces and schools is automatically implied from the previous paragraph. One contextual boundary between the two school related cases is case construction process. In research studies (such as the current study) guided by constructivist paradigm, cases are not given but constructed throughout the course of the study (Ragin, 1992; Yin, 2003). Accordingly, while the researcher was in the field to investigate the first school case (School A-pseudonym) in relation to the mathematical practices identified in case one of workplaces and games, it was realized that it is difficult to understand the issue only from this school case.

Consequently, the second school case (School B-pseudonym) was selected to help increase the understanding of the issue related to the third research question of the study. Geographically, these two schools are located in different two districts (Abergele and Seqota Zuria weredas) and two different climates (Woina dega-subtropical zone and Kolla-tropical zone). Culturally, although both schools are within the Khimra community, they are historically influenced by two other ethnic groups. For example, the Khimra people in which school A is found is influenced by Tigrians and speak Tigrigna fluently, bot the community where school B is located is still Khimra people but affected by Amhara cultures. Moreover, although textbooks and curriculum as well as policy issues are common contexts of both schools, the two schools also have different units of analysis such as teachers that differ in experience of teaching and participation in professional development workshops.

3.2. The Study Site and Selection of Participants

3.2.1. Description of the Study Site

The research site for this study was the Wag Khimra Zone of Amhara regional state with total population of around 426,213 living in seven weredas (CSA, 2007). The two schools were chosen from the two weredas (Seqota Zuria wereda and Abergele wereda). This zone was chosen because the researcher speaks, reads and writes the language (Khimtigna) of the participants, including the letters ኘ ኙ ኚ ኛ ኜ ኞ ኝ unique to this language. Therefore, language didn't become a barrier in the data collection process. Moreover, the majorities of the people who live in villages have no formal education and even do not know how to write and read and not willing to send their children to school. Besides the researcher's personal experience, the low school enrolment can be evidence for this relative to the population of the Zone (ANRSEB, 2009). However, they are observed doing mathematics related practices in markets, workplaces, home and other life activities. This was taken as an opportunity to investigate and understand indigenous mathematical ideas and practices. In this zone, there are seven weredas or districts called Seqota town, Seqota Zuria, Gazgibla, Sehala, Dehana, Ziquala, and Abergele.

Abergele wereda (district) is located in the northeast of the zone where the zone is bounded with Tigray regional state (see Figure 2) and has a total population of 43,191 (21,976 male and 21,215 female) peoples. This district was one of the research sites of this case study. In this district, there are 35 schools. From these, one is KG school, 13 first cycle (grades 1-4) schools, 20 comprehensive (grades 1-8) primary schools, and one high school. Of the 33 primary schools, 4 schools use Amharic as language of instruction, 4 schools use Tigrigna as language of instruction, and 25 schools use Khimtigna as language of instruction. According to the officials of the education bureau of the district, the enrolment in 2013/14 academic year is about 11,258 (6042 male and 5216 female) students. Moreover, there were 306 teachers in primary schools in the same academic year. Of these 135 (79 male and 56 female) teachers are grade 10 complete, 7 (3 male and 4 female) teachers are 10+1 certificate holders, and 164 (115 male and 49 female) teachers are 10+3 diploma holders.

According to these officials, all textbooks except science and mathematics textbooks of primary schools are prepared in the local language and by considering the local people's socio-cultural practices. However, as these officials informed to the researcher during the data collection process, since the politicians and administrators of the district give less attention to education and there is shortage of transportation, about 45,000 books are still in stores and not distributed to schools. The officials excluded science and mathematics subjects from the above description although there are mathematics textbooks written in khimtigna language. The reason why they excluded these subjects is that because the contents in these subjects are less contextualized with the indigenous cultural ideas of the people. English, mathematics and natural science subjects are mentioned by the officials as difficult subjects to most students in the district. According to the officials, English is difficult because it is second language to the students and the teachers are not competent in that subject. Mathematics and science are difficult subjects since the instructional practices do not connect these subjects to students' real lives and the students have negative attitude towards these subjects (especially. mathematics and physics).

With regard to educational wastage and quality in mathematics education, of the 2762 (1512 male and 1250 female) grade one students sampled by the wereda education bureau, 2181 (1213 male and 968 female) students were reported to be competent in mathematics. Of the 210 (119 male and 91 female) grade 8 students sampled by the wereda education bureau only 72 (43 male and 29 female) students were reported as competent in mathematics. However, the reasons for such failure are not explicitly mentioned by officials. One of the primary schools in this district was, therefore, selected as a school case to treat the issue related to school mathematical practices in relation to points examined in workplaces. The pseudonym for this school is School A. Comprehensive and in-depth interviews were conducted with each of the key participants, students and teachers. In the presentation of participants' sayings, each participant's pseudonym is used.

Seqota Zuria Wereda is one of the seven districts of the Wag Khimra Zone. It surrounds Seqota Town in all directions. This wereda has a total population of 112,396 (56, 245 males and 56, 151 females) with no urban area (CSA, 2007).

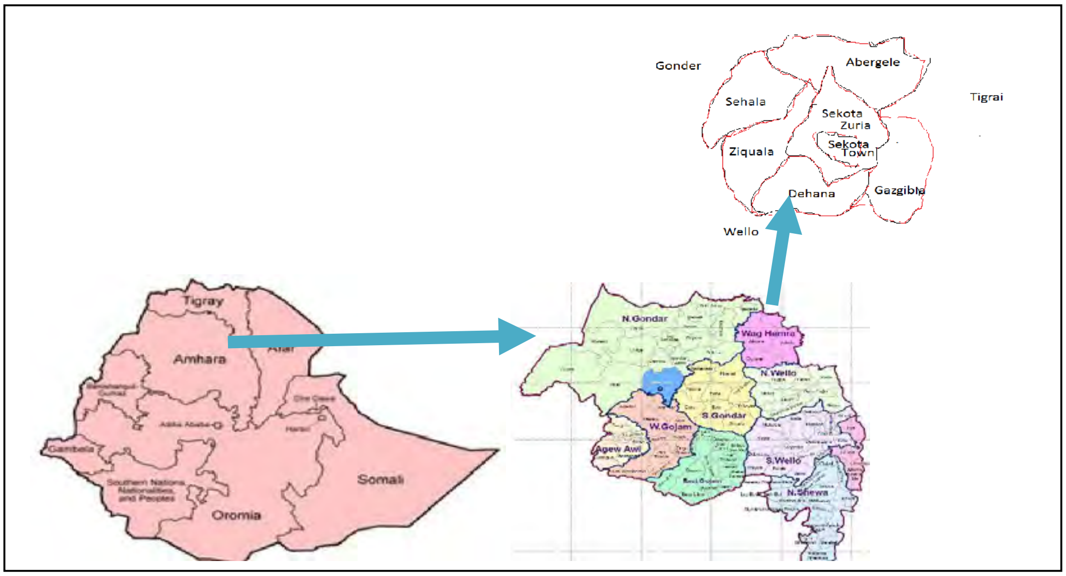


Figure 2: The site of the study (Ethiopia → Amhara Regional State→ Wag Khimra Zone (this is a hand sketch))

It was difficult to access the officials of this district in order to get contextual information for the study. The difficulty was caused not because of lack of systematicality of the study but because the officials were called suddenly to the Regional Government (Bahir Dar) for meeting for two months whiles the researcher had had an appointment with them. Moreover, the delegated officials were not willing to give information saying that 'I have no idea about your issue'. However, as recorded from the brochures posted in the offices, there are about 20 schools which use Amharic as language of instruction with 220 (120 male and 100 female) teachers. There are 46 schools which use Khimtigna as language of instruction with 379 (208 male and 171 female) teachers. One of the 46 Khimtigna schools was included as a case in the current study, School A.

3.2.2. Selection of Settings and Participants

According to Stake (1995) and Yin (2003), qualitative understanding of a certain phenomenon depends upon careful and appropriate selection of cases or units of analysis and participants. The target population of workplaces and schools was all the workplaces and primary schools that exist in the zone. First, asking friends and officers in the zone, the workplaces and games available in the zone were listed. Those workplaces that involve government and non government institutions such as hotels and contractor related construction workplaces were omitted from the list because it was believed that it would be better concentrating on the traditional practices. From the definition of everyday practice (given in chapter 2), it would be possible to study the omitted workplaces too, but since time and economy wouldn't allow this, the focus was on some selected ones. Moreover, most of the workplaces omitted (construction, carpet laying, nursing, etc) have been researched before in other situations of different countries.

Accordingly, the eight different workplaces namely farming, weaving, pottery, sewing craft, traditional brewing, shop, shoeshine, house construction, and the two games i.e. gebeta and tirga were included in the study. These were selected because the persons that work in these workplaces and those participate in games were expected to use traditional mathematical ideas, concepts and procedures to perform their tasks and they are communities of practices to be models for how mathematics teaching and learning should proceed in schools. Before the visit to the selected districts, the researcher was not aware of the fact that there could be sites with no some types of workplaces and hence the initial proposal was to select at least one workplace and school from each district. However, although farming and merchandise workplaces are available everywhere in the Zone, workplaces such as weaving and crafts were not available in Abergele district while there were several such workplaces in Seqota town and Seqota Zuria Wereda. So, this situation was reconsidered and since the workers who worked in any of these workplaces performed similar duties, there was a freedom to choose participants from any of the Weredas based on their availability. To examine how everyday indigenous mathematics is recognized and used in classroom mathematical practices, teachers and students were included in the study as they are directly concerned with the practices of mathematics teaching and learning.

After deciding how many workplaces or games or schools to include from each site and after having permission (see Appendix A for letters of permission for entry in to the sites) from local governors, the next step was selecting and visiting participants and asking their volunteer participation. There was a friend of the researcher assisting in the process of selection, discussion on the participation and interviewing participants.

Among the methods and procedures we followed to get participants were visit, greet them, introduce ourselves, explain why we visit and want them, ask their opinion to be respondents, if they agree, give or read the informed consent form (see appendix B) and get them signed on it, and finally ask for appointment. The non-probability sampling techniques employed here were the purposive and snowball sampling methods (Creswell, 2007; Yin, 2003). No screening criteria was used to select participants of workplaces such as traditional weaving, craft, house construction, and herding since there are very few in the zone. However, in workplaces such as merchandise, the first criterion was voluntariness and willingness to be audio taped because many of whom we visited refused participation and only few accepted.

Table 1: Description of Participants

Site	Setting	Gender of Participants	Age	Participant's pseudonym	2013 G.C. Interview date : period	(2013 G.C.) Observation date : period
Abergele	Traditional brewery	Female	42	Atalelech	Aug. 12: 1:30 - 2:10 PM	Same day
	Farming	Male	68	Abera	Nov. 20: 4:00-4:50 PM	Nov. 20: 9:00-11:00AM
	Game	Male	14	Arega	Nov.13: 3:30-4:20 PM	Nov.13: 3:00-3:30 PM*
	School	Male	27	Ameha	Nov. 15: 1:30-2:10 PM	Nov.18: 11:10-11:50am
		Male	22	Alula	Nov. 18: t 1:00-2:00 PM	Nov.19:t 9:20-10:00AM 11:50-12:30am
		Female	13	Asselefech	Nov.19:t 10:40-11:10 AM	Student
		Male	15	Assefa	Nov.19: 12:30-1:00 PM	Student
Seqota town	Weaving	Male	47	Sitotaw	Jul. 12: 1:30-2:20 PM	Jul. 16: 2:30-4:00 PM
		Male	78	Shegaw	Dec. 9: 4:30-5:20 PM	Dec.10:9:00-11:30 AM
	Tilf	Female	40	Tilma	Dec.17: 1:30-2:10 PM	Dec. 18 at 1:00-1:30 PM
		Male	32	Gulesh	Jul. 24: 3:00-3:50 PM	Jul. 25: 9:00-11:00AM
	Pottery	Female	38	Shege	Dec.13: 1:00-1:35PM	Dec. 13: 10-11:50AM
	Shoeshine	Male	27	Shuwaye	Jul. 9: 10:00-10:50 AM	Jul. 9: 2:00-1:00 PM
		Male	19	Shumete	Dec. 3: 3:30-4:10 PM	Same date
	Shop	Male	29	Teshome	Jul.17: 10:30-11:20 AM	Jul. 18: 8:00-10:00AM
Seqota Zuria Wereda	Pottery	Female	45	Kesre	Dec.22: 11-11:50 AM	Dec 23: 9:30-11:30AM
	Farmer	Male	49	Fasika	Jul 15: 9:00-9:58 AM	Jul 16: 10:00-12:30AM
		Male	43	Fasil	Dec.16: 10:30-11:20 AM	Dec.16: 8:30-10:20 AM
	House construc	Male	53	Genana	Dec. 5: 11:00-11:50 AM	Dec. 5: 9:00-11:00AM
	Game	Female	23	Atitegeb	Dec. 20: 12:40-1:20PM	Dec.20: 10:30-11:30AM
	School	Female	33	Neyni	Dec. 10: 8:30-9:20 AM	Dec.11: 10:00-10:40AM
		Male	28	Zelalem	Dec.12: 1:00-2:00 PM	Dec.13: 10:00-10:40AM
		Male	26	Kakhisho	Dec.12: 9:00-10:00 AM	Dec.12: 10:00-10:40AM
		Female	14	Kore	Dec.13: 10:40-11:15 AM	Student
		Male	16	Zereay	Dec. 12: 10:45-11:15 am	Student
		25				

The next criteria were accessibility and variety. For example, in the merchandise type workplaces rather than making only shops, we tried to include traditional brewing and shoeshine boys for the sake of variety of contexts. All participation in this study was based on voluntary. Once they understood that researcher's intention was to learn as much as possible about their work and the interests were purely academic, they decided to participate in the study.

In selecting schools, distance and accessibility were the criteria. Another criterion was the language of instruction in grades 1-6. That is why a school was not included from the Seqota town since the schools in this town do not use Khimtigna as their language of instruction in grades 5 and 6. Students, who can express their ideas openly, mature in age, with good academic performance in mathematics and other subjects, and exposed to extracurricular activities, were expected to fit the purpose of this study. Teachers were used to identify students who fulfill these assumptions. With regard to selection of teachers, the only selection criteria was being mathematics teacher in the selected school and grade level since there are only few such teachers. Since, in the upper primary classrooms (grades 5-8), the text books hardly use indigenous mathematical practices, there seems a need of studying indigenous mathematical knowledge in relation to the mathematics concepts taught in these grades. Accordingly, the selected teachers and students as well as their classrooms were taken from grades five and six. Another reason why grades five and six were selected was that due to the units of analysis. Since students are among the units of analysis, the researcher though that students of grades 1-4 are not mature enough to provide qualitative information about the issue and to describe their classroom practices in relation to their real lives. However, since there was a problem of getting an experienced teacher, the researcher tried to be flexible and recruit teachers of grades 1-4 based on their experience as teachers of grades five and six in previous years. The reason for the scarcity of experienced teachers is not due to lack of systematicality of the researcher but due to transfer of teachers from one school to another throughout the Wag Khimra Zone. One reason for the transfer of teachers is that when teachers who can speak or teach in the local language graduate with diploma in mathematics they have to replace other teachers with certificate or those who cannot teach using the local language i.e Khimtigna.

One reason for not including grade seven and eight students and teachers is because the teachers who teach grade five and six are also teachers for grade seven and eight students. The other reason was that the language of instruction in these grades of all schools is English which could have created a communication gap. To this end, all the selected participants speak Khimtigna. Thus all the informal and semi structured/formal interview sessions were conducted in Khimtigna. For the formal interviews, the interview questions were translated from English to Khimtigna for the participants, and then the interview audio data was transcribed in the original language and translated back into English for the purpose of recording and analysis.

3.3. Methods of Data Collection

Data for case studies can come from multiple sources such as documents, observation, and interviews (Creswell, 2007; Stake, 1995; Yin 2003). According to Yin (2003), it is necessary of: "(a) using multiple, not just single, sources of evidence, (b) creating a case study database; and (c) maintaining a chain of evidence" (p. 85). These principles are related to the data collection, the data analysis and reliability issues of a case study respectively. In the data collection stage, multiple sources of information were used to address the research purposes of this study. The researcher made in-site observations and wrote field notes and reflections, examined documents, and scheduled interviews with the selected participants. This multiple source approach is used in order to ensure accuracy and alternative explanations that result in data triangulation (Stake, 1995). Data collection was conducted in two phases.

The first phase was the two month (July and August of 2013) field work targeted to the first case, mathematics in workplaces. During this period, six workplaces viz. traditional brewing, weaving, sewing craft, shoeshine, shop, and farming were selected. After observing the activities, interviewing individual respondents, having field notes, and examining related documents, the data was analyzed and a temporary and draft report of this case was produced. The analysis and report of this phase helped the researcher to improve many aspects of the study for the next phase. The second phase of data collection was conducted in the two months (November and December) of the year 2013. The above procedures were repeated with some improvements in this second phase of data collection for cases 2 and 3 in the two schools. Moreover, during this phase, some workplaces which were impossible to get in the previous phase (due to rainy summer season) were investigated. The methods and their corresponding instruments of data collection used in each phase are described in the following subsections.

3.3.1. Interviews

Interviews were one of the most important sources of information in this case study. Two types or forms of interviews were used, informal conversations or unstructured interviews and formal or focused interviews. These interviews were open-ended in nature because the researcher frequently asked participants for their opinions and views on the issue based on the in-situ (workplace or in site) observations. The researcher chatted informally with the participants before and after their working hours, during their break times, on the road, and in the play ground with herders. During these informal chats, we discussed topics related to their overall work, their use of mathematics at work, and the problems they faced at work or school. Just immediately after departing from the participant or when there is an interruption of the chat, the researcher jotted down short notes about the relevant issues raised in the chat, wrote summaries about these informal chat sessions, and included them in the field notes for that day. Observation sessions were always accompanied by short informal interviews, which took place whenever an opportunity arose or at break times. These sessions helped the researcher to obtain clarifications about unclear issues. By the way, formal interviews are structured or semi-structured and in-depth interviews in qualitative study. According to Hatch (2002), formal interviews are:

> structured in the sense that the researcher is "in charge" of leading the interview, there is a set time established for the interview, and they are most often recorded on tape. They are semi-structured because, although researchers come to the interview with guiding questions, they are open to following the leads of informants and probing into areas that arise during interview interactions. They are in-depth in that they are designed to go deeply into the understandings of the informants (p. 94).

Formal or semi-structured interviews, which are appropriate for case study research, are interviews that include predetermined and open ended but flexible questions that help to focus the discussion (Hancock & Algozzine, 2006). Structured interviews of the yes or no types limit the discussion to a predetermined answer and that of unstructured interviews facilitate the discussion to flow unfocused. However, semi-structured interviews solve these problems by preparing framing questions to focus the interview to the purpose of the study and follow up questions for detailed information (Hancock & Algozzine, 2006). Open-ended questionings, to elicit a response that informs and answers the research question, were used to allow the individual respondents to define the world in their unique ways (Seidman, 2006) followed by probes to help particularly shy respondents.

Formal or semi-structured interviews were conducted at the workplaces or homes based on the suitability of the area and agreement with the respondent. The interviews were audio recorded and later transcribed. Notes were taken during the interviews as back-up for sudden loss of audio taped data. In some cases (for example, when reflection was needed in solving mathematical tasks), two interviews were conducted with some participants that lasted from 50 minutes to one hour and if additional information was needed, one interview otherwise. In particular, teachers were interviewed twice, before and after the classroom observations but the second interview sessions took short period (about 10-15 minutes). The details about number and period of interview times are given in table one.

With regard to the instruments, a semi structured interview protocol was used for the different interviews. Interview instruments were first prepared in English and then the local language version was produced and implemented to make interviews clear and ease of communication. This protocol included open ended interview questions, contextual computational tasks such as word problems, and plain mathematical problems to be solved by participants in workplaces and students. The plain and contextual mathematical tasks were included in order to examine and understand how context affects mathematics doing. The interview protocols used in the field are given in appendices C, D and E.

3.3.2. Observations

One purpose of the study was to examine and understand how everyday mathematics is integrated in school mathematics teaching and learning. To this end, the interaction of teachers and students were observed in the classroom. School pedagogical centers and the activities and conversations in different workplaces were observed and recorded using an observation protocol. A "checklist of elements" in the observation protocol included: the physical setting, the activities and interactions, and conversation. In addition to the structured observation instruments, field notes, verbal descriptions, and observer comments were written as memos, and pictures were taken when the situation allows. Each observation was accompanied with informal interview with the participants of the workplaces and classrooms in order not to miss data from simply observing.

The researcher sat with all the workers in their workplaces as part of the field visits and observed them and their activities. Workplaces were observed two times. At the first visit, in addition to introducing the purposes, informal observations (for about 30 minutes) of the situation were made in order to identify aspects of their practice that were relevant to the current study. The information gained from these preliminary observations and chats was recorded as part of the field notes and used as data. During the second visit, actually after the formal interview, the researcher formally observed (refer to table 1for the time it took) their work-related activities. It is formally because at this time, observation protocol (see Appendices F and G) were used to record everything observed by staying for a long period in the process of activities. During these sessions, the physical setting, the participants, their roles, their activities and interactions, and the duration of their activities were noticed and recorded. These field visits and observations helped the researcher gather in-depth information regarding their work-related activities. Observation sessions took from 40 minutes of classroom observation to about two hours in workplace observations.

3.3.3. Documentation

Documents that were examined and used for this study were teachers' lesson plans and textbooks as well as teachers' guide books. From lesson plans, the teachers' use of examples, models, and ideas was examined in relation to cultural and workplace mathematical practices. General information and statistical data of the zone, presentation of traditional mathematics related puzzles and poems written by reporters and journalists, and any educational information related to the current study were collected from news papers and magazines. Newspapers and magazines were read to collect statistical data about the Amhara region and the Wag Khimra zone. These documents helped the researcher to triangulate the data gathered from the participants' work-related activities (Yin, 2003). In order to manage the data properly, each document was collected and recorded into a document log. Each document was separated and logged by type including lesson plan, textbooks, news papers and magazines. Accordingly, data were pulled out from such categories of documents whenever necessary for analysis.

Table 2: Summary of instruments used in the data collection process

Instrument / Case	Observation checklist	Semi-structured Interview protocol	Contextual math tasks	Plain math tasks	Documents
Workplace/game	✓	✓	✓	✓	✓
School A	✓	✓	✓ *	✓ *	✓
School B	✓	✓	✓ *	✓ *	✓

*Only for student participants

3.3.4. Field Notes and the Researcher's Personal Reflections

According to Patton (2002), field notes are detailed descriptions of observations made in social and physical settings and interactions. He also identifies two types of information in a field notes, descriptions and reflections. The descriptive information "should be dated and should record such basic information as where the observation took place, who was present, what the physical setting was like, what social interactions occurred, and what activities took place."(p. 303). In the descriptive part of the field notes, the researcher wrote about the participants' physical settings, their activities, and their conversations. Direct quotes were also included whenever what the participants said when they interact each other and with the researcher seemed relevant to the issue. The second information, reflective part, contains the researcher's own feelings, reactions to the experiences, and reflections about the personal meaning and significance of what have been observed (Patton, 2002). When observing the participants and their activities, the researcher's own critical reflective thoughts of what is seen, heard, felt, and experienced were recorded as part of the field notes. The field notes include reflections about how the researcher sensed these experiences (i.e. methods) and about the problems and failures encountered.

Table 3: Summary of the sources of data for each research question

Research Question	Data Sources
What is the structure of the overall work-related activities of the participants in each selected workplace and game? How is mathematics embedded in such activity structures?	• In situ observations • Field notes • Informal and semi-structured interviews regarding their work-related goals • Personal reflections
How do the goal-directed activities of the selected workplaces and their inherent mathematical activities influence one another?	• In situ observations • Field notes • Responses/solutions to contextual tasks linked to their practice, word problems, and plain math tasks (from the formal interviews) • Audio tapes of semi-structured interview sessions regarding their responses to tasks • Personal reflections
How do in-and out-of-School mathematical practices interplay? And why do they interact in the way it is?	• Documents such as textbooks • Classroom observations • Responses to contextual tasks linked to their practice, word problems and plain mental computational tasks (from the formal interviews) • Audio taped semi-structured interview sessions regarding their responses to tasks • Transcriptions of interviews • Personal reflections

3.4. Data Analysis

A qualitative data analysis is a triangular process of three related activities viz. describing phenomena, classifying the descriptions, and seeing how the identified concepts interconnect/interact (Dey, 1993). According to Dey, in qualitative data analysis, an important step is thick or thorough description of the data that includes "context of action, the intensions of the actor, and the process in which the action is embedded" (p. 32). An important frame that he suggested further is that a qualitative data analysis should be seen as an interactive spiral process which starts at the data level, then description of that data, then classifying, then searching connections back, and finally producing the account. At each level/stage of the spiral, the analyst/researcher may find fresh views of the data, look down the previous level, evaluate his/her methods of how he/she arrived at that level, and looks for alternative and easy ways to go to the higher level (Dey, 1993).

This shows that data analysis proceeds continuously starting from the beginning of data collection up to the stage where the researcher is confident that a complete story can be produced for writing findings (Creswell, 2007; Dey, 1993; Hatch, 2002; Merriam, 1988). Therefore, data collection and data analysis of a case study research are simultaneous processes. So, the first data analysis begins with "the first interview, the first observation, and the first document read" (Merriam, 1988, p. 119). This means that it is possible to employ several levels and procedures of data analyses. Three levels of data analysis were employed in this case.

Level one is about the data analysis during the data collection process that helped the researcher to reshape the study according the context (Hatch, 2002). To identify mathematical aspects of participants' workplace activities, information from several sources such as field notes, and documents were carefully examined. The participants' responses to the formal or semi-structured interviews and solutions to written or oral contextual and plan mathematics tasks or problems were also examined. This analysis guided to restructure future interviews, omit or add respondents, and observe additional settings. The researcher's field notes and personal reflections were reviewed at the end of the day in order to improve methods of recording and reflection, as well as other issues that needed further attention in the future observation and interview sessions. This process of analyzing data as the data collection proceeds helped the researcher to avoid the risk of ending up with repetitious and shortage of data (Yin, 2003).

The second level of data analysis was the creation of a case study database. Partially analyzed data of each case from level one were organized chronologically and case folders were created for the participants in this study (Naresh, 2008). Each of these folders included the following information about participants: their background, their photographs if any, and their individual stories about the manner in which they were inducted into this study. Moreover, each folder included a narrative that includes information about participants' workplace activities, their work-related goals and mathematical activities, and a summary of the informal chat sessions with the participants. The transcripts of formal interviews with the participants and their solutions to the mathematics tasks were also placed in each corresponding folder.

The information from these individual folders were synthesized and categorized into certain themes by forming tables of data. Data from level one were read through several times and categories that represented emerging themes (hence classification level of Dey's (1993) spiral of data analysis) looked for. The researcher also looked for commonalities and differences in themes regarding different participants and then used matrices (a) to display these categories and (b) to provide evidence using excerpts from interviews. This case study database formation process acted as a repository from which the researcher was able to view and review the evidence as and when needed (Dey, 1993; Naresh, 2008). It also has considerable role in increasing the trustworthiness of the case study since the documentation of all procedures and activities in the first case study helped the researcher to repeat similar steps in the subsequent case studies. Moreover, if an auditor to this study wants to conduct similar cases, it is possible to repeat these documented procedures, instruments and activities and get similar results.

The above two levels were used in the two phases of data collection to produce the respective three draft reports for each case and finally put as sections 4.1, 4.2 and 4.3 in this paper. The third level of analysis is using the theoretical framework, Saxe's (1991) framework, to further analyze the data from the case study database. During this stage of data analysis, the researcher made explicit connections to the research questions by using relevant aspects of the framework. To answer Research Question 1, the participants' emergent goals and activities were described using the first component (practice-linked goals) of Saxe (1991). Further, to aid the discussion regarding Research Questions 2 and 3, the researcher tried to describe (a) how the activity structure, artifacts, interactions, and their prior understandings of the practice influenced the emergent goals and mathematical activities in the workplaces; (b) components of school mathematics present in the work-related mathematical activities in out-of-school workplaces, and (c) everyday mathematical components that contributed towards the teachers and students' mathematical activities

3.5. Trustworthiness

According to Naresh (2008) and Yin, (2003).), case study is a triangulated research strategy which intends to provide theoretical insights from a small number of participants In this study, the triangulation approach of validation was achieved by using multiple resources that involve testing the same proposition by data gathered from multiple sources such as observation, interview, documents, field notes, reflections, and member checks. Any design is, therefore, vulnerable to threats of credibility, transferability, dependability, and confirmability (Creswell, 2007), which are the concerns of this section as discussed below.

Some of the threats of Credibility (traditionally called internal or construct or face-validity) are failure to develop sufficient operational meanings of concepts and subjective judgment during data collection and analysis (Yin, 2003). To increase credibility, triangulation of multiple data sources (interviews, direct observation, and documentation), were used during data collection process (Creswell, 2007; Yin, 2003). This is because convergence of major themes in the data from these multiple sources leads strong credibility to the findings (Yin, 2003; Maykut & Morehouse, 1994).

Moreover, Member check (which is asking research participants to tell the researcher whether he/she has accurately described their experience and opinions) was used to further enhance the credibility of the study and to refine interview questions and enrich data during the field work. Member checking complemented triangulation method of checking credibility by exposing the results and report to participants for critics (Maykut & Morehouse, 1994). In this case, the researcher requested the participants to read and give their feedbacks on the transcriptions and the interpretations attached to them. After commenting, the participants put their signatures on the form given at the end of these documents.

The threats to Transferability (conveniently called applicability or external validity) are related to the problems of generalizability and design issues (Yin, 2003). To increase transferability, analytical generalization of particular set of results was done to a broader theory or proposition (Yin, 2003). This is to mean that the multiple realities found from this study are attached to the sociocultural and constructivist theories as well as to the principles of ethnomathematics discussed in chapter two. To achieve this theoretical generalization, the replication logic was used in the sense that the themes and descriptions are produced from replicating categories in the three cases. Thick descriptions were also used to increase transferability by argueing based on context-rich evidence (Creswell, 2007).

According to Yin (2003), the primary goal of testing for dependability or consistency or confirmability (these are qualitative terms replacing for the quantitative term reliability) is to minimize the errors and bias in a case study. This is related to the consistency of the data and data collection techniques used. In a qualitative research study, approaches such as triangulation, maintaining a case study database and an audit trail can be used to minimize threats of consistency (Yin, 2003). Data base and audit trail were used to show how data are collected, how categories are derived, and how decisions are made during the field work (Maykut & Morehouse, 1994). To this end, a research folder that provided information regarding early propositions concerning the project; correspondence and suggestions between the researcher and the participants; personal thoughts that summarized the researcher's understanding of the project at different times and stages; and road maps of how tasks have been done was maintained. Moreover, since biases may result from interview questions, interviewer and interview situation, they can be minimized by careful planning to solve these errors and preparing for flexible actions. For example, the interview questions and protocols were prepared in such a way that they are relevant and focused to the purposes. Further, the researcher submitted the draft about the interpretations of the data to the supervisors and they provided independent evaluations on the reports.

3.6. Ethical Issues

Ethics shows the important principles of conduct guiding those relationships between researcher and participants in the study. The principles include, among others, issues of informed consent procedures, confidentiality toward participants, and benefits of research to participants over risks (Creswell, 2007). To guarantee for potential risks of participants due to participation in this study, a consent form was agreed on. The consent form was read to each participant before the interview begun. The consent form stated the purpose and scope of the research. The researcher also informed all participants that he would use pseudonyms to protect their identity unless they wanted to use their real names. When the participants agreed to participate in this study, they were assured that the information collected would specifically be used for this study and for academic purposes only. The participants trusted the researcher and shared their personal information. Any information regarding any of the observations and interviews with participants was not revealed to their superior authorities. It was hoped that the knowledge that comes out of this research study proves beneficial to the participants of this research study by unlocking and documenting their indigenous mathematics, in addition to informing the mathematics education community.

For the purpose of interview and observation data management, each of the interviewees was given a pseudonym similar to the real names of Ethiopian peoples. Schools were identified by letters A and B.

CHAPTER FOUR

PRESENTATION OF DATA AND RESULTS

The literature presented in chapter two discussed about the current situation of ethnomathematics in general and everyday or workplace mathematics particularly. It indicated the variations on definitions and perspectives, as well as the difference among researchers and educators on the awareness of its educational and classroom implications. It also reviewed the gaps in variety and depth of the researches conducted in this field. The purpose of this study was, therefore, to investigate workplace mathematics and its educational implications from the perspectives of workplace practitioners, students, and teachers in Wag Khimra Zone of Ethiopia with the intention of filling these gaps.

This chapter presents the data and findings of the present case study in three sections. The first section presents the context of the workplaces, games, and schools. It discusses the structure and goals of work related activities of participants from workplaces and games. It also highlights the context of the two schools including physical and educational background. The second section deals with the mathematics embedded in the activities of participants in workplaces and games under thematic categories developed throughout the data collection and analysis process. In the third section, school or classroom mathematics is described from the two schools and the teaching materials. School mathematical practices are described in relation to the findings of workplace mathematics discussed in section two. It includes the awareness of teachers, students and textbooks about the out-of-school mathematical practices, the extent of using the out-of-school mathematics in the classroom, and perceptions of students and teachers on the interaction between the two. Text books and teacher's guides of grades five and six were considered and reviewed with respect to these points.

It is necessary to clarify about the case analyses and presentation of data, at this juncture. Many case study related books and authors (for example, Yin, 2003) recommend a case study researcher to present each case's data and discussion first and then cross analysis of the cases in a separate chapter or section. However, there is no rigid rule of analyzing and presenting case study data in qualitative studies such as this. This means that the strategy of analysis used by a case study researcher depends on the data and context at hand. For example, according to Yin (2003), it is possible for a multiple case study report to have no separate chapter or section for each case. Rather the entire report may consist of cross case analysis and the information from the individual cases would be dispersed throughout each chapter or section of themes emerged from the data. That is what is happened in this paper. In order to reduce redundancy, the two school related cases are presented under one heading with subsections of common themes emerged from the data. The information from each of the schools/cases is presented in the respective section/theme it fits with. That is why the first case is presented separately in section 4.2 but the two school cases are presented under a merged and common heading as in section 4.3. This section is, therefore, cross analysis of the two school related cases. The cross analysis of the three sections is discussed in chapter five.

4.1. The Context

In section 3.2, the study site, description of participants, and the participant selection processes have been described holistically. In this section, the structure and the work related goals of each workplace are presented to lay the context for the next sections of this chapter. Moreover, the contexts of the two schools are described.

4.1.1. Activities of Participants in Workplaces

Although out-of-school setting includes many aspects of life activities that occur outside an educational setting, the current study was confined to only workplace and game settings. To examine and describe the mathematics at different workplaces and games, it is important, therefore, to have information about the overall features of a given workplace or game in relation to mathematical practices. This means that it is necessary first to understand the process, procedures, rules, and other contextual aspects of the setting before trying to examine mathematical aspects.

> Whether organized and structured human activities are characterized as work or play, their mathematical content is difficult to locate and appreciate if one does not first grasp the purposes, processes, and organization of those activities (Smith III, 2002; 113)

Work is one of the activities that engage humans for the purpose of production and service that are important to both producer and consumers of products and services. According to the above quotation, therefore, it is difficult to understand and uncover the mathematical parts of the workplace activities if the structure and procedures of the whole activity is not examined first. What is the activity structure of each workplace and game as it is observed in the field? How do participants describe their activities? How do participants react to mathematical problems outside their work? This subsection tries to address these and other related questions. There are eight workplaces and two games considered in this study. The eight workplaces are pottery making, traditional cloth knitting, farming, house building, traditional brewing, shop, shoeshine, and weaving.

The Pottery Making Workplace

Some crafting occupations such as pottery making and smith in Ethiopia have been traditionally given to some part of the community with few households until recently (Bula, 2008). This is because pottery and goldsmith are among the less recognized careers and people engaged in these workplaces are marginalized by the community (Kaneko, 2007). The men of such a household do metal work such as jewelries, medallions, and farming instruments such as hoe and plough whereas the women are responsible for making clay pots used for cooking and preparing food and local beer (Kaneko, 2007). The pottery making workplace is considered in this study.

The pottery workplace is a traditional factory of ceramics with raw materials such as soil, processes such as molding, and products such as pot. The process of pottery making starts when there is available order from customers or demand in the market. It follows a structured cycle of four phases. During the first stage, customers may come and order the material they want or the potters themselves may go to neighbors and market places and ask some people or other potters which materials are in high demand. After knowing the type of material to be produced, the potter begins the work in the second and preparation stage by fetching a special type of clay soil from a special place called 'Arfitse' (a hill like place naturally formed from collection of soil); this soil is milled and mixed with donkey dung and with water; and then hitting this mixture repeatedly by a stick, it is mould in to the shape they need. This molded shape is then exposed to air/wind to dry for 3-4 days and this dried mold is taken into fire and ripened for at least one day to strengthen it. On the sixth day of the process, another decorational art is done by scratching and removing any rough things from both inner and outer surface of the material using sharp objects such as broken horn or rib bone of animals or glass and using butter or oil so that the surface becomes smooth and good looking. The pottery making activity is seasonal that occurs from September to May and becomes dormant during the rainy season of June-August. Two woman participants were included in this study from the pottery workplace (see table for more information). Both participants have no any experience of formal education.

The Traditional Cloth Knitting Workplace: Tilf sev

In Khimtigna language, 'tilf' means the art of decorating and 'sev' means work or job. 'Tilf sev', thus, is the professional practice of decorating traditional cotton cloths of men and women by putting or drawing motifs or patterns through the process of sewing or knitting with colored threads called 'Hidyat' and needle. It is possibly done by both men and women. It is not a kind of workplace that produces cloths but rather it is a service provision related workplace because customers themselves provide cloth and other necessary instruments including the design they need. The responsibility of the crafter is to put the needed designs on the cloth using the colors chosen by the customer. It is a profession that engages only one person in the work.

The structure of this workplace is also cyclical in its nature with four phases. The first phase is receiving cloth and deciding what design to use. The second stage is preparation by making sure that all necessary instruments and materials such as needle, colored threads, charcoal, and sometimes time scheduling are available. The third phase is putting the design on the cloth using charcoal or pen, and then performing the actual craft of making 'tilf' according to the design. The final fourth stage is submitting the crafted cloth to the customer and collecting the service fee. From this workplace type, two participants were selected. Whereas the female participant has no formal educational background, the male one is still enrolled in teacher training college.

The Farmer's Workplace

Farming is a process that takes around a year from preparation up to harvesting crops. This process has a structure of four phases. The first phase is preparation phase which runs approximately from the mid of December up to mid of May. Activities in this phase include cleaning the farmland, repeated plowing of the farmland to soften, and preparing seed corns. The second phase is making the final plow and sowing seeds. These sown seeds grow up within two or three weeks. The goal in this phase is to saw the right type and amount of seeds on a given farm land so that they will grow with moderate distance from one another i.e. not very crowded and not very scattered. The third phase is the weeding phase when unwanted plants are removed from the main crop plants. The fourth phase is harvesting which includes activities such as cutting the heads of these grown and ripen seed plants; accumulating these cut-off heads in the form of 'Guchique' (a collection of cut-off heads of crop plants i.e. the parts that contain the food crops); preparing a circular place called 'warine' where these accumulated cut-off heads can be thrown down and hit by animal legs (usually oxen) for the purpose of separating the straw part and the food crop. Three participants of the farming workplace were included in the study. Two of them have no any formal educational experience but the other does have and he is a priest.

The House Builder's Workplace

House construction has many forms. But only the traditional house building was included. This traditional house building is not practiced in the form of contractor but as employed service because every material needed for building the house is covered by the owner of the house. Only one house builder participated in this study. He is 37 years old farmer with some educational background from Adult Literacy Program (ALP). He can only build the wall of a house exclusive of its roof because the roof of the house is completed by another person skilled in that career. He uses instruments such as rope, hammer, a meter, and a hoe.

After fixing employment related issues such as negotiation on the salary, food expenses, time of completion, hiring co-workers, and other emergent conditions, the house builder becomes responsible for the following activities. The first is laying the base by first measuring the dimensions of the house and making marks by stretching a rope and then digging on the ground according to the marks and the direction of the rope. This is performed cooperatively with the co-workers. The second responsibility is making cobblestones in the form of rectangular prism. The stones are made available by other co-workers and the builder prepares them as cobblestones. Side by side, the builder orders other co-workers to prepare the cement or mud. The final and third stage is building the walls of the house. During this phase, he has to determine the limit of the house's height, the doors height and position, as well as the position and size of windows. One male participant was included in this study from house building workplace.

The Traditional Beer Making and Selling Workplace

The traditional beer making and selling house is a place where 'shilla' is brewed and sold. 'Shilla' is the name of this traditional beer in khimtigna language. Its Amharic name is 'Tella' and the house where this 'tella' is prepared and sold is called 'tella bet'. Usually, women are engaged in this type of work. The process of traditional 'shilla' brewing starts by preparing the 'buqil'(malt formed from crops such as barely) that involves soaking in water of the selected grain such as barely for at least 24 hours, germinating the barely which may take 3 days, and drying the germinated barely by exposing to sun's heat for 1-3 days according to the availability of sun's heat. Then this dried malt is grinded in a traditional mill to crack/crush and turn it to powder. Parallel to this activity the hop is bought, cleaned and crushed to change into powder. The powdered malt and hop are poured into a container (e.g. pot) and then water is added so as to mix and create a mash. This process of creating mash is called 'tamisiseno' and it takes about 3 days if the place has enough heat and 4 days if the place is cool to ferment this mash.

Next, corn or sorghum grains called 'shilaque' (crops such as sorghum or corn used for this purpose) are grinded in a traditional mill, then this powder is mixed with water and baked to produce bread like appearance called 'Digo', and then this baked bread or 'Digo' is broken down into pieces and poured into a larger container/kettle such as 'Gen' and the mash is added in to this same container to mix them. After 24 hours if the place is cold and after 3 days if the place is hot, water is poured into this mixture to make the final alcoholic drink called 'Zillil'. After 2-3 days, this 'shilla' is opened and tasted. Then selling starts when customers come into the house. One female traditional 'Shilla' brewer who has no formal educational background was a participant 0f this study

Shop Owner's Workplace

This is a shop based merchandise workplace. The shop based retailing merchandise in this study has similar structures and phases as Saxe (1991) described the street selling of Brazilian children except a shop is stationary market place but street selling is portable market. So, preparation to purchase, purchase, preparation to sell, and selling are the four phases of the work related cyclical structure of shop merchandise. In the preparation to purchase phase, the shop owner analyses on the questions such as what items are fully sold, which items are liked by most/many customers, how much money should be spent to buy these, and where can these items be found? The purchasing stage is going to a specific market or store and buying items in wholesale form and transporting to the shop. The third phase of the structure is preparation to sell and includes activities such as deciding on prices of each item to be retailed and organizing the items in a place visible to customers. The sell phase is the final stage which involves advertising and retailing/selling the goods.

The *Shoeshine Workplace*

The shoeshine workplace is a place where one individual (usually young boys/men) cleans and brushes shoes of customers. But sometimes it is possible to shoeshine work place owners to do additional activities such as retailing items related their activity such as socks. The shoeshine person first buys different colored inks or paints from shops and retails it when he cleans shoes of customers. The customers are made to pay for service and cost of the ink used.

In this workplace, the primary goal at the beginning (usually in the morning) is to make more money by working at least on 10 or 15 persons' shoes. To achieve this, they need to shout (sometimes mentioning the price to show it is cheap) to people who pass along the road saying 'shall I make your shoes beautiful only for 4 birr?' or they have to own more customers. The activity structure of this workplace is similar to the shop owner's workplace. Two young men of grade six and four participants were selected from this workplace.

The Weaving Workplace

Traditional cloth is woven on a loom, a device that holds the 'mihin' (warp threads) in place while filling threads are woven through them. Weaving has the procedures described below. The first step is purchasing cotton and remove its seeds and other impurities using hand and an instrument traditionally called 'madamecha'; then create threads by spinning on 'miftil' (a hand held spinning pin) to form a 'mismis' (a collection of threads); and then transferring this thread into small collections on a material called 'kelem' (bobbin). It takes 1-2 weeks depending on the woman's energy and speed. The next step is purchasing and processing 'ziha' (yarn) which includes throwing or stretching and then rearranging on wheel called ‘ziha malene’ (stretching the yarn), then insert this into a warm mixture of wheat powder and water, and then taking it out after some time and exposing to sun’s heat to dry it. This process takes one day. The third step is the weaver’s responsibility to take the ‘ziha’ (yarn) and thread it through the loom to form a series of parallel threads. Then he starts weaving by feeding the filling threads from the side of the loom by bobbins, which are changed manually when the yarn runs out. The fourth and final phase is selling the produced garment and earning money. One of the two participants from this workplace has formal educational background of up to grade ten and has attended trainings related to his job.

4.1.2. Activities of Participants in Game Setting

In their daily lives, people engage in different cultural practices. They engage in their work, participate in social events such as weeding and meeting, be part of festivals and holiday carnivals, play games and other recreational competitions, and may engage in traditional sport. So, game is one of cultural practice that can engage individuals both children and adults. Games are activities or contests governed by set of rules and played for recreation purpose and to develop mental or physical skills. In the selected site, Wag Khimra Zone, there are many games played. Some of the identified games are ‘dibo’(playing with spherical solid stones of small size), ‘khankes’ or ‘sinu-siliz’ (balancing body on one leg and pushing a flat stone), ‘gegne’(involves two teams that play in opposite direction to kick a small wooden ball by using stick), ‘tirga’, ‘geveta’, ‘chivsheno’(hide and search). Only two of these games were considered in this study, ‘tirga’ and ‘geveta’. Whereas the game ‘tirga’ is played usually by children of 7-17 years old, the game ‘geveta’ is played by all ages. Both games engage 2 or more players at a time.

The 'Tirga' Game Setting

This game is a form or type of gambling where winners take zippers but not money. This game engages more than two children (usually herders). The physical environment of the game needs a small flat stone, a small hole of about 1-3 cm radius (like the round target cavity in golf) on a clean surface or flat ground, a mark (usually a bigger stone or wooden stick) about 2-3 steps far from the small hole, and coat zippers (small tablet like flat object used as traditional zip for coats and is called 'Meketeria' in Khimtigna language).

In play, the game has its own unique rules. The first rule is that each participant child should contribute one Meketeria from his/her pocket to assure that s/he will play at least the first round of the game. The next rule is determining the queue of the turn taking. To determine who should play first, each throws his/her zipper to the direction of the small hole by standing on the mark. If there is disagreement on who should begin, then one player measures how far each zipper of the players is from the small hole. The player who owns the closest zipper from the small hole is the beginner of the game. The turns of the next players are determined according the closeness of his/her zipper to the small hole next to the player before him/her.

After the game begins, there are also other rules to be implemented in the next steps. The beginner collects one zipper from each participant including himself and throws all one by one to the small hole. He will own/win only those zippers accumulated in the hole. Other wise, he will be told to kick any of the zips outside the hole by the small circular stone (this order is given by the next turn player and the zipper to be kicked should be chosen in such a way that he will face difficulty to kick it or possibly the stone enters the hole). If he hits the particular zipper, he will win all the zippers and the game will be over and start another round. If he misses kicking the ordered/given zipper, the next player will play with the remaining zippers with similar procedures. If the stone enters in to the small hole while he throws to kick the ordered zipper, the player will lose all the zippers (both in and out of the hole) and the next player takes his turn. The goal of each player is to win more zippers for two reasons.

First, he will be appreciated by friends for winning many zippers. The second and most important is decorating his cloths (coat and trouser) by zippers both in quantity and variety. So, to win more zippers from the game, he must be able to through perfectly at the target without waiting the other players' weaknesses. Although, the players were three in this case as observed in the play, only one was interviewed to reduce redundancy of ideas. The participants in this game were 12 (player 1), 14 (Arega), and 15 (Player 3) years old boys who are at the same time looking after goats in the field. All have no educational background and speak Khimtigna and Tigrigna languages fluently.

The 'Geveta' Game Setting

This is a traditional stone game common in other parts of the country, too. It is similar to the mancala game practiced in other African countries or in other cultures in the world. This game is included in the traditional sport games like chess by the zone's sport authority. Traditionally, the game is made on a flat stone by digging 12 circular holes and by filling each hole with four small stones (sand) or grains such as corn or pea. Two or more players can engage at a time by having equal number of six or less holes.

Two (male and female) players were engaged in the game. They are both student teachers who came to the site village for practicum purpose from Seqota College of Teacher Education (SCTE). Another young woman, who is a waitress of the café where the game was going on, was observing the player and waiting her turn. The male student teacher is 26 years old and teaching aesthetics. The female one was a 23 years old language teacher. In this discussion, my interviewee's (the female teacher) pseudonym is Atitegeb and the other player is named 'player 2' for the sake of discussion when needed. Although I observed and talked informally during the play, I interviewed the female student teacher.

To decide the first beginner, the players clamp their right hands, hide to their back, and bring to the front with some fingers stretched and others folded. The front finger beats the three fingers below it, five fingers beat any other finger including three fingers, and the back (small) finger beats the front finger. This way, the one who beats the other will begin the game. There are two types of geveta. One is called 'Liwet ekhurseno' (breeding cow) and the other is 'Nigs' (its literal meaning is becoming a king or crowning but practically it means taking or wining the opponent's houses or holes).

In the play, if the game is 'ekhurseno', the player will pick all the four grains from his holes, move clockwise by putting one stone in each subsequent hole, picks all the grains from the hole he arrives and does the same until he arrives in an empty hole. On the way when this player is playing, if any previously emptied hole is again full of four grains from his territory, he will take the grains at any time. If he arrives on a hole of the opponent with three grains, he will make four by adding the grain he brought and take away and continue playing. If the first player arrives at an empty hole, he will put the grain he brought and game is over. To know the winner of a particular round, either they will count the grains they collected and accumulated or they put four grains in the holes and identify who owned more holes. The player who covered more holes (houses) using these accumulated grains will be the winner of this particular round.

4.1.3. School Contexts

To understand how school teachers, students, and curriculum or teaching materials make sense and use of the workplace mathematics to enhance their practices, two schools were also included in the study from two districts. School A was selected from Abergele wereda and School B was considered from Seqota Zuria wereda.

Context of School A

School A was established in 1993 and is now one of the 33 (20 schools for grades 1-8 and 13 schools for grades 1-4) primary schools in Abergele wereda. This school enrolls students of grades 1-8. There were 565 students enrolled in grades 1-8 in the academic year 2013/2014. Language of instruction in this school is Khimtigna in grades 1-6 and English in 7th and 8th grades. In this same year, the mathematics textbook to student ratio is 1:3 in grades 1-4, 1:5 in grade five, and only one (the text book used by the teacher) in grade six.

Although it was difficult to get the overall school education data since the director was out of office, the vice director told the researcher that 70% of grade eight students who took the regional exam both in 2010/2011 and 2011/2012 academic years failed to pass to grade nine. The reasons are three folds. The first is that the language of instruction is English in grade seven and eight but since the teachers are not competent in English, they teach using their local language yet the exams are in English. The second reason is that students frequently miss classes due to family and other problems. The third one is due to shortage or lack of reference materials. The vice director says, “There was no library in the school until 2013 and even this newly established library has no reference books for students and doesn’t either have a librarian except our teachers open it in shifts”.

In this school, there is only one mathematics teacher for grade five and six. In search of variation and new ideas and views, one mathematics teacher of grades 3-4 was included. So, two 22 and 27 years old young teachers participated in this study from this school. Both teachers were new comers to the school but the 27 years old teacher of grades 3-4 taught more than five years in other schools of the same wereda with his certificate in teaching. Both are new graduates of teaching from SCTE with 10+3 diploma in teaching mathematics. Two, a 13 years old 5th grade and a 16 years old 6th grade students, also participated.

Context of School B

Seqota Zuria district has 70 primary schools. Of these 48 schools (22 are grades 1-4 and 26 are 1-8) use Khimtigna as language of instruction, but 22 schools use Amharic as language of instruction. School B was selected from the 26 schools that teach grade 1-8 students. This school is established in 1994 and located in rural place with total area of 30,000 square meters. There are 27 teachers of which 12 are males and 15 are females in this school. The teacher to pupil ratio in this school is reported to be 1:45 by the school management at the present time (up to December, 2013). With regard to textbook to student ratio, it is achieved 1:1 in grades 1-4 but it is low as the grade level increases.

In this school, there is one library in one of the rooms around the staff lounge. Also, there is one pedagogical center in which some science models, mathematics related shapes such as triangles made of cartons, local materials such as drum for teaching music, and charts. Tutorial classes are arranged under a tree which is also used as a place where students eat their food. Three teachers participated in this study. The female teacher participant teaches in grades 1-4. The other two male teachers teach in grade five and six (see table 1). Two student participants were also included in the study one from each of grades five and six.

Teaching materials

Teaching materials such as textbooks and teacher's guides were also analyzed. It is important to note at the beginning that both grade five and six textbooks and teacher guides are written in khimtigna language. However, it is totally a translation from Amharic version. So, the author of grade five and six textbooks is an Amharic speaker and not member of the khimra people. The translator and editors of teacher's guides of both grades are khimtigna speakers but the translator has biology background and the editor has chemistry bachelor's degree. The translator of both grade five and six textbooks is 'Khimira' (member of khimra people) but has chemistry background. The editor of grade five textbook is 'khimra' and is a mathematics teacher in SCTE. But the editors of grade six textbook are both 'khimit' (plural of khimra) but their educational background is not mathematics.

Moreover, for both grades, the author's intension is to present mathematical contents in local language so that learners can understand the subject better. All textbooks, in the schools I visited up to the end of December 2013, have colored covers but their inner appearances are in black and white. Given these contexts and facts, the teaching materials were analyzed and discussed in terms of motivational factors that include practical implications and real world problems. These textbooks were examined in terms of how examples and tasks refer to real lives in order to give the students meaningful contexts and connections to familiar experiences (Berish, Thaçi, Jashari, & Klinaku, 2013).

The grade five mathematics teacher's guide includes introductory part that discusses about how to teach, assessment methods, student mark recording techniques, and time table of periods and topics to be covered. The grade five mathematics textbook is organized into five chapters namely: Chapter 1-Whole numbers and the Four Basic Operations; Chapter 2-Working with variables; Chapter 3-Fractions, Decimals and the Four Basic Operations; Chapter 4-Data Handling; and Chapter 5: Geometrical Figures and Measurement.

The grade six mathematics textbook has similar organizations as that of grade five except content difference. There are six chapters: Chapter one-Basic Concepts of Sets; Chapter Two-Divisibility of Whole numbers; Chapter Three-Fractions and Decimals; Chapter Four-Integers; Chapter Five-Solving Linear Equations and Inequalities; and Chapter Six-Geometry and Measurement.

4.2. Mathematics in the Workplace and Game Settings

The activities of participants in their workplace and game are presented in the previous discussion. This section tries to uncover the mathematical part of these activities both from the participants' actions and perceptions. Five themes emerged from three processes of the researcher's activities. The first is from the process of data collection and analysis conducted in the eight workplaces and two games. The second is from the analysis of textbooks and teacher's guides as part of data collection and analysis in schools. The third is from the review of the literature with particular reference to Bishop's (1988) categorization of environmental activities that involve mathematics. According to Bishop (1988), there are six categories viz. counting, locating, measuring, designing, explaining and playing, which use and produce mathematical ideas and procedures. The grade five and six textbooks present mathematical topics such as numbers, working with variables, data handling, basic concepts of sets, measurement, and geometry. Moreover, the data collection and analysis process conducted throughout this study produced the themes such as number sense and arithmetic, algebra (variables and functions), measurement, time, direction, probability and chance, money, geometrical shapes and their properties, and perceptions as well as ways of doing mathematics. Using these three points as criteria, the following themes were used as sub headings to present and analyze the data related to the mathematics embedded in workplace and game settings.

- Number sense and arithmetic
- Algebra: Sets, variables and functions
- Probability and Chance
- Geometry and Measurement
- Location and Direction

Although these themes are mainly related to the first basic research question of this study, they are connected to the other two basic research questions. It is because if one doesn't first identify and understand the different mathematical concepts and techniques used in everyday setting, he/she will face a problem to talk about how activity affects mathematics doing (research question two) and to discuss how these everyday mathematical practices are integrated in school mathematics. The connections of these five themes to the research questions will be clarified when each are presented and discussed as in the following subsections.

4.2.1. Number Sense and Arithmetic

This theme includes counting, numbers, number systems, quantitative reasoning, fractions, decimals, integers, ratio and proportions, the four operations, multiples and divisors, comparisons, and other number related aspects. Bishop (1997) identified some mathematical practices of cultural groups that should be categorized under counting. These include, "mental abilities of numerical reasoning, mental calculation, quantitative reasoning, and numerical reckoning…The mathematical ideas derived from this activity are numbers, calculation methods, number systems, number patterns, numerical methods, statistics, etc" (p. 6). This shows that every real life activity of people in different cultures involves mathematical ideas. But how do people perceive mathematics? The name and conception of mathematics is narrowly related to only some mathematical concepts. For example, for the potter, mathematics is all about thinking because to the probing question, 'does counting and calculating mean thinking?' she explained as follows

> Yes, counting and calculating involves our mind's thinking. I have to think the amount of water and soil needed to make a dish or pot. When I sell my products and when I buy 'Asfeza', I calculate and count by thinking in my mind (Shege, 13/12/2013).

The mental calculation and counting are considered as thinking because these activities are performed mentally. They consider all the mathematics related activities inherent in the work are counting and thinking. Of course even the name for mathematics, in the textbooks that use khimtigna language as instructional medium, is called "Egize-Khasib" which means thinking with numbers where 'Egize' means number and 'Khasib' means thinking. So mathematics, according to the Khimra people, is all about thinking. This view of mathematics is, of course, a result of their contextualized use of mathematics. When they engage in counting situations, they call mathematics is all about counting and if they do mental computations, they perceive mathematics as thinking. Such mental computations and other mathematical practices are inherent within the actual activity of each phase of the pottery workplace.

Moreover, the use of mathematics for perfection purpose shows another perception on the importance of mathematics for everyday life. The following extract describes this.

> …If the threads in the cloth are visible to our eyes (e.g. Gavie, Netsela, and Qemis), we count these threads to go in any direction and make a sketch of the design and we sew. This is useful for our design to be perfect i.e. to make equal lines, to know where to turn or bend. If the threads of the cloth are not clearly visible to count (eg. if the cloth is Abo Jedid), the design and marks are

> drawn arbitrarily and there is no any mathematics involved as to my knowledge (Gulesh, 24/7/2013).

After getting the cloth to be crafted from customers, the sewing artisan draws the desired picture and shape on the cloth and starts the sewing activity using needle and colored threads. To this participant, 'tilf' making (sewing art) is classified as mathematical and non-mathematical. So, mathematical knowledge and practice helps to the perfection of the 'tilf' making activity. Mathematical counting of threads on the cloth helps another mathematical activity to emerge, geometrical design and drawing. But, how do people count? What arithmetical techniques do indigenous people use to count?

Counting is related with the number sense and used to know the quantity of something such as money or cattle. For example, a herder explained how he knows and checks whether all the cattle exist in the field, "*I know the quantity I had in the morning and I count frequently all the day and in the evening and compare with the morning quantity. If there is difference, it tells me either loss or mixing with other's cattle*." (Arega, 13/11/2013). This is quantitative reasoning that shows number sense in this workplace. It should be clear that the intention here is not to equate reasoning and counting but rather to show that the reasoning technique used to justify whether or not there in a change in number of cattle is counting them to know the difference between original and currently counted number. The frequent counting is accompanied with finding differences and comparing between quantities.

Counting and numbers, to the khimra people, have their base in the number sense and quantity of physical objects around them. For example, an elder priest tells a story of the development of numbers in relation to objects with permanent quantity as follows.

> The number one comes from the singleness of the sun in the sky because whenever and wherever, the sun is one. Two is related to the number of sexes (male and female) of every living thing. Two also represents the two events of

> a day, night and day. Three is named from the three legs of a traditional stove formed by arranging three big stones called ‘kalen’ and putting firewood to ignite in the space between them and then putting the dish on them to make soup. Four is related to the four limbs of animals. Five is related to the fingers of a person’s hand or foot. Six is named from the six directions that a person can change his/her face i.e. up, down, right, left, front, and back. Seven comes from the number of days within a week, Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, and Sunday. A female dog is believed to have eight breasts. This is the cause for number eight. For nine, I don’t remember.

This shows that numbers were created from the quantitative reasoning of physical objects. But the names are given in relation to unchanging quantities of these objects such as the sun is one for ever and the number one is derived from it. The development of numbers is also related to the development and use of the khimtigna language. For example, the priest participant (Fassika) expressed his feelings that counting and numbers come from language and learnt from elders.

> I count by saying one, two, thirty, forty and etc. and calculate by adding and subtracting…..These counting and numbers come from our Geez and ‘Khimtagna’ languages……how I know this? I heard from elders how they count and calculate during my childhood. And as I told you before, I am a religious leader. So, I learnt numbers and operations in church when I attended church education. At this age I am supposed to serve the church and people. So, I read religious books in Geez language in order to cite bible. One of these books is called ‘Bahire-Hasab’ which tells us about how to calculate calendar. Based on this book, I tell the worshipers the religious holidays…. How can I detect numbers except counting them orally and in the language? What we see and can touch are the objects to be counted and calculated, such as money (Fassika, 15/7/2013).

This tells that the mathematical practices are learnt from ancestors by language and religious practices. In replying to the question “what do numbers look like?” Priest Fassika suggested that it is difficult to detect them but their effects are seen in real objects through counting. This implies that numbers are abstract representations of quantity. The way numbers are counted and the origins of these numerals are also described in terms of language and religious practices. So, counting is not only used in work related activities but also in religious activities related to praying.

> When a priest orders or leads the praying, he says "egzio meharene kiristos belu 12 gize", the worshipers will start counting the joints of the four fingers by using their thumb. They start from the top joint of the baby finger down up to the third joint at the bottom, then start at the bottom joint of the next finger counting the three joints up, then starts from the top joint of the middle finger down, then starts from the bottom joint of the fourth finger and ends at the third and top joint of this finger. This gives a total of 12 repetitions of the phrase "egzio meharene kiristos" (Fassika, 15/7/2013).

This extract shows not only the use of counting in religious practices but also it has another important mathematical concept in it, the concept of factors. That is three and four are the factors or divisors of 12 or to the reverse that 12 is a multiple of 3 and 4. The techniques of counting using fingers and the joints of fingers is also common practice in other countries and cultures (Rosin, 1984).

It is common to borrow or lend payable money or other materials in the situation of business and economics. This trend is used by most mathematics books and teachers to teach integers and negative numbers. But it is possible to find such borrowing and lending practices within the students' daily lives and workplaces such as farming. In the third stage of the farming process, unwanted plants or weeds are removed through an activity called weeding. It is usually done cooperatively in groups called 'wufere' (a group of people working for one farmer) or 'libine' (a kind of borrowing labor to pay later or for already paid labor) where peers help a farmer to remove weeds from farmland on time. The aim of working together in the form of 'wufere' is to remove the weeds from a farmland quickly so that the crop plants can grow freely on a suitable field before the rainy season ends. When a farmer wants to form a 'wufere', he/she need to prepare lunch or dinner for the participants in the 'wufere'. This requires determining the number of participants according to the capacity the farmer can feed them and according to the time it will take to remove the weeds in a single day. What is the difference between wufere and libine then? The farmer described the difference as follows in response to this question.

> Wufere means a collection of people to help a farmer in weeding or plowing. It is not mandatory for the farmer to payback to the participants of the 'wufere' but should prepare lunch. On the other hand, 'libne' is a collection of people to help a given farmer but the farmer is obliged to pay back. For example, if five persons participated in the 'libine', the farmer has borrowed the labor of five persons to pay back later. When this farmer participated in a weeding or other activity of one of the persons who helped him previously in a 'libine', he has canceled one payable laborenergy, and so on (Fassika, 16/7/2013).

Based on his/her capacity to afford food for every participant and inability to pay the borrowed labor, the farmer should decide either 'wufere' or 'libine.' According to this extract, when the farmer organizes a 'libine', he/she is prepared to pay later the labor borrowed from each participant. So, the difference between 'wufere' and 'libne' is that the later is payable and no need of worrying for lunch or other expenses. The first day the borrower pays to one of his peers, who lent labor, he is decreasing his borrowed labor by one, and so on. This means the negative five becomes negative four. This shows the conception of negative numbers and cancellation.

In relation to comparisons between quantities and sizes, ordinal mathematics is also observed in out-of-school activities. This is observed especially in games that require turn taking. 'Tirga' is one such game. To determine who should play first in this game, each player throws his/her zipper to the direction of the small hole by standing on the mark. Then one player measures how far each zipper of the players is from the small hole. The player who owns the closest zipper from the small hole is the beginner of the game. Take a look on the following example. As described in the previous section, player 1 and player 3 were not included as participants in the study but since the following extract is taken from the actual observation of the play, they appear as player 1 and player 3. After throwing the zippers there was argument between Arega and player 1 on who should begin. To solve this argument, player 3 became a judge and measured the distance of each player's zipper from the small hole.

> Mine is clearly far from the hole but let's measure yours if you don't agree. (He stretched his hand making the elbow on the edge of the hole towards player 1's zipper. Since there is still a gap, he put 3 fingers of his other hand in the gap). Have you seen? (When player 1 and Arega responded to this question showing that they agreed on the actions) Let's measure similarly (calling Arega's name) zipper (he put similar hand measure towards Arega's zipper but still there is a gap. He then stretched the three fingers of the other hand but at this time the gap could not place all the three fingers. Then he bended one finger and tried to put the remaining two fingers). So, he (pointing to Arega) is the first player (Player 3, 13/11/2013).

This is how the turn taking queue of the game is decided. This ordering was in the mind of each player when they start the game. However, according to this extract, measurement was not consciously planned part of the activity but emerged when the disagreement and then interaction occurred at any stage of the game structure. This is because each player seeks to be the first turn taker because he/she has the advantage of winning all zippers of that round. Therefore, ordinal sense is inherent in this game.

Fraction and decimal related numbers are also familiar in the everyday work related activities. This is evident in the local names sizine-for quarter or one-fourth, showune-for one-third, giver/qiran-for half or one over two, and tsiqant-for one-tenth. For example, the response to a contextualized division related task given to the herder brought another use of fractions in their work related practices. The question was "if your parents decided to divide 8 cows in to four of their children, how many will be your share? If you have two friends and if you divide one bread among you three equally, what part will be your share? Please think aloud how you do the problem and give your reason."

> It is 2 because when you divide 8 to 4 persons, they will take 2 each….If we divide one bread to three of us, I would take the showune (one third)….How I learnt this name and calculation? Before a year, I was employed in another house because we hadn't our own goats. That time, when my father made agreement I heard this name and asked him what it means. He told me that

> ‘showune' means taking one out of three goats which are bred during your stay (Arega, 13/11/2013).

According to the culture of the participants, when a herd boy is going to be employed, he himself or his parents will negotiate with the employer. This negotiation of salary is not in terms of money but it is in terms of animals. The agreement may be called ‘giver’ (half) or ‘showune’ (one-third) or ‘sizine’ (one-fourth). If the agreement is a ‘giver’, the herdsman will count the number of new offsprings starting from the first day of employment up to a year. Then at the end of the year (after serving one year), he will own half of the new calves produced within this year. Similarly, if the agreement is a ‘showune’, he will own the one-third of the new goats or cows of the year. This trend is not practiced only in herding but also in other employment and borrowing situations. For example, when a farmer is employed to plow another person’s farmlands, he will make such negotiations to take the one-third or one-fourth of the crops he produced. Therefore, students of Wag Khimra Zone are familiar with such experience of fractions. This claim is similar to findings from other researchers related to fair sharing practice of fractions outside school (Saxe, Taylor, McIntosh, & Gearhart, 2005).

Decimals are perceived in terms of cents of monetary related activities. This is observed in the solution process and answer to the question “What is the half of 214? What about if 214 is divided for 3?”

> The half of 200 is 100 and the half of 14 is 7. So, 100 plus 7 is 107.....The 180 gives 60 and the 30 will give 10, 10. The remaining is 4 which devides one to each. Now, I remain with the 1 which will be 30, 30, 30 cents to each of the three. So, one third of 214 will be 71 and 30 cents. The remaining 10 cents will go to one of them since it may not harm the others. (Kesre, 22/12/2013).

In the question, there is no any word that tells about money or cents, but the respondent explained her answer in terms of cents. When she was asked why, she replied as, “What can this very small number be other than cents? Otherwise it will not have meaning" This shows that decimals are there as mathematical knowledge of the people but they are represented only in terms of cents which is one evidence that shows mathematical concepts are understood according to their functional context. Moreover, since coins below the 5 cents are not common in the everyday life of the people, Mrs. Kesre could not go further to divide the remaining 10 cents into three. The only thing she did is to add the 10 cents to one of the three one-thirds. This is to some extent similar to the primitive and ancient Ethiopian mathematical practices of priests, that throw out from the calculation process decimals as evils, as described by Olivastro (1993) in chapter two. Mrs. Shege solved the same problem as follows.

> The half of 200 is 100 and the half of 14 is 7. So, it is 107. If we divide 214 into three equally, they will get 'showune' each… 'showune' means taking one out of three parts….. the 30 will be 10,10,10; the 90 will be 30,30,30; then when I make 40,40,40 it will be 120; when it is 50,50,50 it is 150; when it is 60,60,60 it is 180; when it is 70,70,70 I will have 140 plus 70 which is 210. So, the 210 will divide for the 3 persons to be 70,70,70. I am remaining with 4 birr only which will be 1 and half, 1 and half , 1 and half . Thus, they will get 71 birr and half (Shege, 13/12/2013).

In this extract, too, the approach of solving the problem is not that much different from the previous respondent in the first part. For the case of division by three or to get one-third of 214, the approach of division is different. The respondent first introduced the concept of 'showune' (one-third). Instead of dividing the 214 to 3 to get 'one-third of 214', Mrs. Shege started from the bottom by adding a multiple of ten three times starting from 10 and going through 70. Then she got a sequence of multiples of both 3 and 10 i.e. 90,120.150,180, and 210. So, she got that one-third of 210 is 70. The mistake she made is dividing four to three. This might be caused due to the absence of the concept of decimals in the culture where traditionally cents are considered to represent decimals and fractions. Therefore, the two extracts given above as responses to the plain question reveal that context has an important role in tackling mathematical problems.

In relation to arithmetic, the four basic operations are performed using different techniques. One of the techniques is counting money in activities related to business such as buying and selling. For the contextualized mathematics problem “If you sell 5 dishes 15 birr each, how much money will you have totally?” a potter described the way she would solve the task.

> It will be 75 birr. How? I will count the money I received. Do you think I don’t know how many objects I have sold? I will receive 15 birr when I sell the first dish, 30 when I sell 2 dishes, this way I will get 75 birr for the 5 dishes (Kesre, 22/12/2013).

Mrs. Kesre calculated in her mind and spoke out only the answer at first. But after some probing questions of how she got the answer, she forwarded the means and procedures. There are two methods here. The first method is counting the total money after selling all the five dishes. This method shows that money related arithmetic is simply solved by counting the money. But, the counting method or process itself has the sense of addition or increment in it. The only prerequisite here is to know the money notes. This method of arithmetic using counting objects to add is also common in other cultures and countries (see for example, Neuman, 1997; Rosin, 1984). Although it seems that adding through counting is universally practiced by any culture, the use of culture context specific artifacts such as money makes the process/technique different in different cultures. Moreover, the use of historically developed cultural artifacts to count or compute is not common in academic mathematics that used canonical rules. The second technique is pair wise addition. Another important issue here is that the potter did the calculation mentally. Such mental arithmetic is common when people are engaged in work related activities that involve solving mathematical problems related to the work. Mental computation is not only used by unschooled people but also by those who have school experiences. Special kinds of formulae are also used to perform operations such as addition and subtraction. For example, the following conversation was part of negotiation between the knitting craftswoman (Mrs. Tilma) and her customer. The customer provided the necessary information and design of the 'tilf' to be crafted on a traditional dress of her daughter. Mrs. Tilma tried to explain to the customer about the things that influence the price by listing the necessary materials and calculating the corresponding expenses.

> Tilma: Ok! If so, let's calculate it together. The black colored costs around 37 totally, one bundle of green thread costs 13 'kurshen' and 50 'santim', one bundle of blue thread costs 8 birr and 50, one bundle of purple thread costs 6 'kurshen'. Totally, we are going to spend 65 'kurshen'
>
> Customer: I will pay you the 350 birr after you finish the work and here it is for the 'hidiyat' and calculate the balance/change yourself. (She took out from her wallet a 100 birr note handed it to Tilma)
>
> Tilma: (took out 35 birr from her wallet and handed it to the customer) here is your change, thank you!

Although the primary goal and intention in the above conversation is giving and receiving service as well as making and paying money for the service, the negotiations on the prices of raw materials and service fees are associated with reasonable facts. Mrs. Tilma could have told the customer directly and shortly the 65 birr but to explain why, she wanted to list all the costs separately so that the customer can trust her. After the customer left the house, the researcher asked Mrs. Tilma to explain how she got the 65 birr. She replied as,

> I added 37 and 13 in my mind first and got 50. Then I added 8 and 6 to get 14. 14 and 50 is 64. Since the two 50 'santim' become one birr, the total will be 65. This way, I calculate in my mind (Tilma, 18/12/2013).

In this instance, 37+13.50+8.50+6 is computed as [(37+13)+(6+8)]+(0.50+0.50) where the additions in the brackets are first computed pair wise remaining with two addends at the end which combine to give 65. She first simplified the problems in to easily computable problems, solved separately the parts and brought together the parts at the end. Moreover, fraction or decimal parts such as cents are separately calculated and finally combined with larger sums. Also Mrs. Tilma was asked to explain how she knew that the change is 35. At first, she thought that the researcher was challenging her but after some discussion she explained her method as follows.

> I just subtracted! If you ask me again how, I first took 60 from the hundred leaving 40 birr. I know that 5 birr is remaining and if I break down the 10 birr in to two, I will have two 5s. I took one 5 to me and the other 5 to the customer. That makes 35 birr to be given back as change (Tilma, 18/12/2013).

This extract also shows how people compute subtraction problems while they are performing their everyday work related activities. According to this example, 100-65 is calculated as (100-60)-(10/2) which is interesting mathematical formula for at least related problems. With respect to subtraction, some thing can be said from the farmer participants' works. These farmers were asked the problem 'what will remain when we subtract 56 from 98? What about 59 from 98?' Let's look and compare how two farmer participants did it. Actually, they did well in the same way for the first part (i.e. 98-56) but differed in the second part.

> To subtract 56 from 98, we take 50 from 90 which is 40. Then 8 minus 6 is 2. Finally, we add 40 and 2 to get 42. Similarly to the second question, 90 minus 50 is 40 and 8 minus 9 is 1. When we add the two results, it is 41 (Abera, 20/11/2013).

As can be expected for people who do not know the borrowing method of subtraction, this participant solved two different questions using similar method. When this participant was asked to change his answer by probing differently, he could not do so. However, from the interview with Mr Fassil, some important issues were observed.

> Interviewer: What will remain if you take 56 from 98?
> Fassil: What are 98 and 56?
> Interviewer: Numbers.
> Fassil: Amazing! You are asking me to take a number from a simple number which is neither money nor thing. Ok! Let me try for you. If I take the 50 from the 90 I will remain with 40 and then if 6 is taken from 8 it will be 2. So, it will remain with 42.
> Interviewer: What if we take 59 from 98?
> Fassil: Still, I will take 50 from the 90 to get 40 and then take 9 from the 8 which is 1. Now, it is 41.

Interviewer: You took 50 from 90 and got 40 which is right, but when you subtract 9 from 8 you got 1, is that right?

Fassil: I think 9 is greater than the number to be subtracted i.e. 8 and it is not possible. Let me do it again. If I take 50 from 80 I will get 30. Now I am remaining with 18 of the 98 and 9 of the 59. If I take 9 from 18, I will remain with 9. So, the answer is 39.

In the first subtraction problem, although amazed on the bared nature of the numbers, he approached place wise subtraction of the digits, subtracting the tens digit from the tens digit and so on. But in the second situation, first he proceeded as before but when the researcher probed and created doubt in his mind and since borrowing is not understood in such subtractions, he adjusted himself with the situation and approached it differently. The following extract, too, shows that context of the mathematical problem facilitates both the understanding and solving that problem.

Interviewer: Ok! Let's try another calculation. What will be the result when we add 27 and 38?

Atalelech: What are these 27 and 38?

Interviewer: Numbers

Atalelech: Yes I know they are numbers as you read to me but what numbers? Are they goats or money?

Interviewer: Nothing! They are simple numbers.

Atalelech: I can't add numbers for nothing.

Interviewer: Ok! Let's say you have 27 cows and you have got 38 cows from the government's soft net program, what will be the total?

Atalelech: I have 27 cattle and the government offered me 38 more cattle…amazing…..you are making me rich! (laugh) When I add 38 to the 27….em….on that twenty…em….that thirty….em…..(she stayed silent for sometime) it is sixty. Isn't it?

Interviewer: How did you get that?

Atalelech: E…..! When I add this outlier and that outlier

Interviewer: What do you mean by outlier?

Atalelech: Those that exceeded the 20 and 30 i.e. the 7 and the 8.

Interviewer: Ok, you have 20 here and 30 there and also you calculated the outliers separately. What is the total then?

Atalelech: thirty and twenty is fifty, then seven and eight is fifteen….totally I have 65.

She recognized that the bared numbers as numbers but it doesn't give sense to combine them and she asked me what objects these numbers represent. After the researcher helped her by contextualizing in terms of cows, she was happy to solve the problem of addition. She called the numbers that hold the unit's place outliers and added them separately. This is similar to school practice where the units are added first and then the tense are added separately, and so on. Another point is that she got the correct answer after some probing questions. This tells us that, the more the interaction with others, the more she will get a correct answer.

In out-of-school situations and workplaces, addition is not only used to add numbers but also to multiply numbers. Multiplication is done by repeated addition. For example, a potter was asked to reason out how she got 54 when she multiplied 18 by 3. He tried to explain as follows.

> …I have 3 tens which add up to 30. And I have three 8s where the two become 16 and 8 added 16 is the 4 of the 8 makes the 16 to be 20 and 4 added 20 is 24. When I add up 30 and 20 it is 50 and then 50 added 4 is 54 (Kesre, 23/12/2013).

Instead of multiplying 18 by 3 directly, she used addition. Even, in the addition process, rather than adding directly the 18s three times, she (Mrs. Kesre) first split the 18 in to two parts 10 and 8, then added separately to combine the 30 and 24 at the end. This is common practice when they encounter computations with two or more digit numbers. The reason they give for splitting a two or more digit number in to two parts and computing separately is for making the process easier and devoid of making mistakes. This calculation can be written as: 18+18+18=(10+10+10)+((8+8)+4)+4= (30)+(16+4)+4 =30+20+4=50+4=54. In school, this is a multiplication problem but to simplify for beginners and young children, teachers could use repeated addition i.e. 3x18=18+18+18=30+24 (adding tens and units separately)= 54. All these calculations are performed mentally without using pen and paper or any technological devices.

In relation to division, the plain mathematics problem "If you divide 689 to 13, what is the quotient?" was asked to both participants from the shoeshine workplaces. One of them solved it mentally as, "The 650 divides fifty-fifty because 5 times 13 is 65.

From the 39, the 30 divides 3 birr to the 10 and the 9 gives 3 each to the three. Thus, the quotient is 53." (Shuwaye, 9/7/2013). But Shumete (3/12/2013), who is still learning in school, solved it as follows.

689÷13   Since 6 for 13 is impossible I will take 68
68÷13   gives 5
65   (5 times 3 is 15, write 5 and waiting one and 5 times 1 is 5 and with previous waiting one, it will be 65)
3   (subtracting I have 3 and if I bring 9 down here, it becomes 39.
39÷13   it gives 3.
39   (subtraction doesn't bear any remainder)
= =   So, the quotient is 53.

It is clear, from the above two extracts, that there is no difference on the final answer but on the method used. When the sixth grade student was asked to solve mentally and if he can use another simpler method to the same problem, he refused because he thought it is not easy to divide mentally or use another simple method. However, since Shuwaye is far from school and adapted his own mental methods of calculations from experience, he started first from the fact that 65 is a multiple of both 13 and 5 and used this relationship. Then, since the question is given in hundreds, he simply realized that multiplying by 10 the 65 becomes 650 and that of 5 becomes 50. Then subtracting 650 from 689, he got 39. Again, he simplified that 3 times 10 is 30 and so the ten men will take 3 each leaving only 9 birr. This helped him that the 3 men will take 3 birr each from the 9. This also shows that school children are weak in creating new methods other than the school learned formula but when people stay at work, there is possibility of finding relevant and simpler methods from experiences. This extract also shows how arithmetic is practiced.

In some workplaces such as trade related activities, it is common to use calculating machines to facilitate the arithmetic. As the following extract shows, a customer came to a shop keeper and told the things she wanted to buy.

Customer: Give me 2 kilos of salt, one kilo of macaroni, one domestic pasta, two soaps. And tell me the total amount that I am going to pay.

Teshome: 2 kilo salt is six birr (he picks his calculator wrote this in it and pressed plus sign), one kilo macaroni is 17birr (writes this in the calculator and presses the plus sign), pasta is 14birr (write and press +), 2 soaps cost 21 birr (writes and pressed =). It becomes 58 birr.

Customer: Ok! Here is 100 birr and what is my change?

Teshome: (pulled out his table's drawer and picked 4 ten birr notes and 2 one birr notes). Here is 42 birr madam and thank you very much. Take this pack of your items.

Since the customer buys more than three items, the shop owner should use a calculating machine so that errors are minimized and calculations can be quicker to save time. Although the calculating machine is helping him to do the computations when the items are many in number to add, the shop keeper calculated the multiplications in his mind. The use of machine is just to be free of errors in the computations when the arithmetic involves complex and more than two addends.

Quantitative and size comparisons such as greater than and less than, proportion and ratio, and percentage calculations are also inherent in everyday life activities. In the pottery workplace, although practiced via approximation, there is the sense of mathematical proportions and ratios. For example, during the observation session of Mrs. Kesre's workplace, she was pouring soil, water, and donkey dung in to a container for the purpose of forming the mixture to make a traditional dish. The researcher asked her to describe the amount of each component of the compound.

> We simply guess and pour each without measuring the exact amount….that is how my parents taught me at first and after that I use my experiences….But although we guess, we balance the components by adding soil if it looks watery or by adding water if the mixture looks thick. Moreover, all amounts will increase when I want to make a pot or even more if I want to make a huge container called 'Gen'. Accordingly, the proportions of water, soil, and animal dung will vary (Kesre, 23/12/2013).

This extract tells us that the potter estimates the amount of each component added into the mixture. This shows that the proportions of water, soil, and dung will vary depending on the size, type and design of the pottery intended. The example also dictates that all these practices are not learnt from school but from elders and experiences. Related to the process of mixing in the 'shilla' making activity is also the concept of proportion and ratio because failure to control the ratio of each component in the mixture can cause loss.

> In order to satisfy my customers, I have to do all procedures carefully. I should know the 'meten' (ratio) of each component to be mixed when making the 'zillil'. Otherwise, either the 'shilla' will be bitter which shows excessive amount of 'Gosh' or 'Buqil' or it will taste watery due to excess amount of water. As I mentioned earlier, it is important to know the size of the kettle and the amount of 'tassa' of each ingredient needed to make a good 'shilla' (Atalelech, 12/8/2013).

According to this extract, if the amount of 'Gosh' is high in the 'zillil', the beer will be very bitter. If the amount of water is too much, the beer will taste water. Again, if the amount of 'buqil' is too much, the beer will be hard to drink. All these imbalances will create problem in attracting more customers and having all the 'shilla' get sold. This problem needs to be solved while the process is going on. This requires experience with the activity of 'shilla' making which requires knowledge of the ratio of each component.

4.2.2. Algebra: Sets, variables and functions

Since a set is a collection of things, it is possible to find such ideas in out-of-school work related practices. An example of such idea is found in a game called 'geveta.' One mathematical idea here is related to sets. The 12 holes are sets of four elements each. They also show equal and equivalent sets. When a player is playing the game, he/she might end the last pebble on an empty hole which is called 'qut yu', this is an empty set. Another mathematical idea is that the four pebbles are related to number sense. The pebbles in a hole are four, the holes are 12, and the total number of pebbles is 48. This is a number sense especially showing even numbers that can be easily divided into two or any other multiple of 2 and 3 and less than 12. For example, the factors of 12 are 1, 2, 3, 4, 6, and 12. This means it is possible that 2,3,4,or 6 players can play the game at a time. The activity of sharing or dividing equally will follow then. For example, if the players are three, each will have four holes, if the players are six, each will have two holes.

Function can also be drawn from workplace activities. The factors that affect the amount of seed crops to be sown in a given farmland are the type of crop, the time it takes to be harvested, and the priority the farmer has in mind. The area of a given farmland also determines the amount of crop seeds to be sown on that land. What about the factors that influence the product? The following extract identifies such factors.

> If the factors such as rain, fertility of the land, and others are fair and God blesses the season, I expect to get 12 quintals of wheat from my 50 by 50 farmland from initially sowed 50 'Tassa' (Fassika, 15/7/2013).

The intensity and repetition of rain, the area of the farmland, fertility of the land, weed, and animals such as birds and insects influence the product to be harvested. With regard to the traditional conception of area, the relationship between the area of the farmland, the seeds sown, and the product harvested is described in the following extract.

> A farmland that takes a pair of oxen consumes 3 'Tassa' teff or it consumes 1½ kilograms of 'Selit' (oil crop) if a good farmer sows and weeding is done timely. If things such as rain and blessing were good, 3 donkeys of teff would be harvested from the 3 tassa sown (Abera, 20/11/2013).

In this example, the participant explained the issue in terms of cereals common in places geographically called 'Qolla'. It shows that, from 3 tassa of teff sowed in a farmland that can be plowed by one good farmer and a pair of oxen in a day, it is possible to harvest six sacks of teff since three donkeys can carry two sacks each. So, the amount of crops to be harvested depends on the variables such as rain, type of seed, area of farmland, and conditions such weeding. This is a function with dependent and independent variables.

As a farmer has some variables that determine the product to be harvested from a given farmland, a merchant also has factors that influence his/her final profit. For example, if the 'shilla' brewer knows the beginning expenses and amount or proportion of each ingredient she poured into the container, at the same time she can predict how much money she will make at the end. This prediction and the actual result are dependent on some factors.

> I don't know about the number of 'qil' that I draw from the kettle exactly but it is possible to know them from the total amount of money I sold since each 'qil' costs 1 ½ birr. But I know that I get 120 ETB from the small container and I usually get 300 ETB if totally sold and 200 ETB if partially sold from the larger container…..The profit depends on the market. If the market is expensive, there is only very small profit because we buy wood, crops, and other materials in which case our profit is only around 150 ETB and the by-products for our cattle. If the cost of cereals is normal (bought by fair cost) and not expensive, we can get 400 up to 500 ETB and the by-products for our cattle. For the question how I calculate, I subtract and put at a separate place of the expense called 'Ayiniwene' from the total money I have sold and I call the remaining my 'tirf' (profit) (Atalelech, 12/8/2013).

Although they know the size of the container and the amount of mixture in it, the beer makers do not know the exact number of 'qil' drawn from that container since there is a byproduct called 'Khatile'. However, this is calculated indirectly from the amount of money they sold at the end. So, if at the end they make 300 birr from a 'Gen' and if one 'qil' costs 1.5 birr, then this implies that they drew 200 'qil's of 'Shilla' from this 'Gen'. This extract also indicates that there are subtraction and division activities in calculating the profit by taking the difference. This profit and loss calculation is similar to business mathematics/algebra formulated as, $P(x)=R(x)-C(x)$, where P is profit, R is revenue and C is total cost of expenses.

In the academic mathematics community, putting or drawing a given shape or diagram on the coordinate system and studying its two dimensional features is one application of relations and functions. In the ‘tilf’ knitters’ design and drawing activity, graphical representation of relations or functions can be observed (see figure 5 (b))

> When I make the points at the beginning, I have to know their distances both from above and side of the initial point. I do this by counting the vertical and horizontal threads of the cloth. The edges of the picture are then drawn easily following these points (Gulesh, 24/7/2013).

Since the cloth is woven by crossing vertical and horizontal threads, this helps the ‘tilf’ maker to count and to move on a two dimensional plane. The vertical distance of a given point can be taken as the y-coordinate and its horizontal as x-coordinate. In figure 5 (b), for example, a point’s order pair is (30,30) or (7,7). So, the 30 by 30 rhombus is formed by the intersection of the graphs under the four constant relations $f(x)\leq 30$, $f(x)\geq -30$, $f(y)\geq -30$, and $f(y)\leq 30$.

4.2.3. Statistics: Permutation and Chance

Probability and chance related mathematical practices were observed in games such as geveta. As described in the previous section, the game has turn-taking structure. To decide the first beginner, the players press or clamp or bring in friction of their right hands, then hide to their back, and then bring to the front with some fingers stretched and others folded (See figure 3). When the players were asked how they determine the beginner, Atitegeb provided the following explanation.

> First, we have to do the processes called shakhutsheno. In this process, we bring our right hands together, then take and hide to our back, then bring to the front by bending some fingers and stretching others, and then decide the beginner according to the rule of shakhutisheno. If I stretched my index finger and he (the other player) stretched his five fingers or the three fingers below the forefinger, I am the beginner. If I stretched my five fingers and he stretched his three fingers below the forefinger, still I am the beginner. If I stretched my forefinger and he stretched his little finger, he is the beginner. If he stretched his three fingers below the forefinger and I stretched my little finger, he is still the beginner (Atitegeb, 20/12/2013).

From this excerpt, the rule of 'Shakhutisheno' orders that the forefinger beats (wins) the five fingers and the three fingers below the forefinger, the three fingers below the forefinger beat the little finger, five fingers beat the three fingers below the forefinger, and the little finger beats the forefinger. This way, the one who beats the other will begin the game. This shows that both players have equal chance of being the beginner. When the players hide and return their hands, there is no possibility of one player to know about the opponent's action in the back. Each player stretches one finger and bends the others and then both bring their hands to the front at the same time. So there is a chance of wining and losing equally for each player.

Figure 3: Shakhutisheno-a process of determining the beginner player

The sample space is S= $\{w, x, y, z\}$ where w=stretching forefinger, x=stretching the three fingers below the forefinger, y=stretching the last or little finger, and z=stretching the five fingers. What if the two players stretch similar (the same fingers)? What if a player stretched out of these four types/groups of fingers?

> If we stretch different types/groups of fingers, we have equal chance of being the first player (beginner). If both of us bring our hands with the same fingers stretched, we cannot know the beginner. In such cases, we repeat the process again and again until we get difference. If any of the players stretched out of these four types, he/she is new to the game and might cause laugh (Atitegeb, 20/12/2013).

This shows that one category of the events of the above sample space is ww, xx, yy, or zz. In such outcomes, there is no decision and the players should do the process again. If a player stretches out of the types w, x, y, and z, it implies that the player does not know the rules of the game and should learn about it before he/she is laughed at. All other outcomes that cause wining or losing are: wx, wy, wz, xy, xz, yz, zy, zx, zw, yx, yw, and xw. From this, it is possible to calculate the probability or chance that a player can beat his/her opponent.

4.2.4. Geometry and Measurement

Geometrical shapes, construction and designs are practiced everywhere and in any cultural activities including house construction, drawing, and weaving (Ascher, 1988; Bishop, 1988; Gerdes, 1988a; Zhang and Zhang, 2010). According to Bishop (1997), geometrical ideas in cultural activities include shapes, analyzing parts of shapes, relationship between shapes, visualization and imagination, and dimensions. All workplaces and games studies in this research also use geometrical ideas to accomplish their work related activities.

The geometrical shapes observed in the workplaces and games include two dimensional (the case of flat circular stave called 'migune' in pottery making as shown in figure 4 (b) and rectangular farmlands in farming) and three dimensional shapes such as the traditional dish called 'disti' and conical shape called 'qil' of (a) and (d) of figure 4 respectively in pottery making. One dimensional geometrical figure such as lines and two dimensional geometrical figures such as rhombus and squares are also common in the crafting related to 'tilf sev' (knitting craft) of traditional cloths (e.g. see figure 5).

In relation to construction of geometrical shapes and figures, it is possible to find such practices in physical objects and drawing using colored things. For example, when making a 'disti' the potter (Mrs. Kesre) first put a flat object called 'Dikhun' (a flat and dry object made of animal dung) on the ground, then poured tiny sand soil on it, then she put the wet clay mixture on this tiny sand soil and started molding the clay upwards using her hands by punching with her fists or her clenched hand.

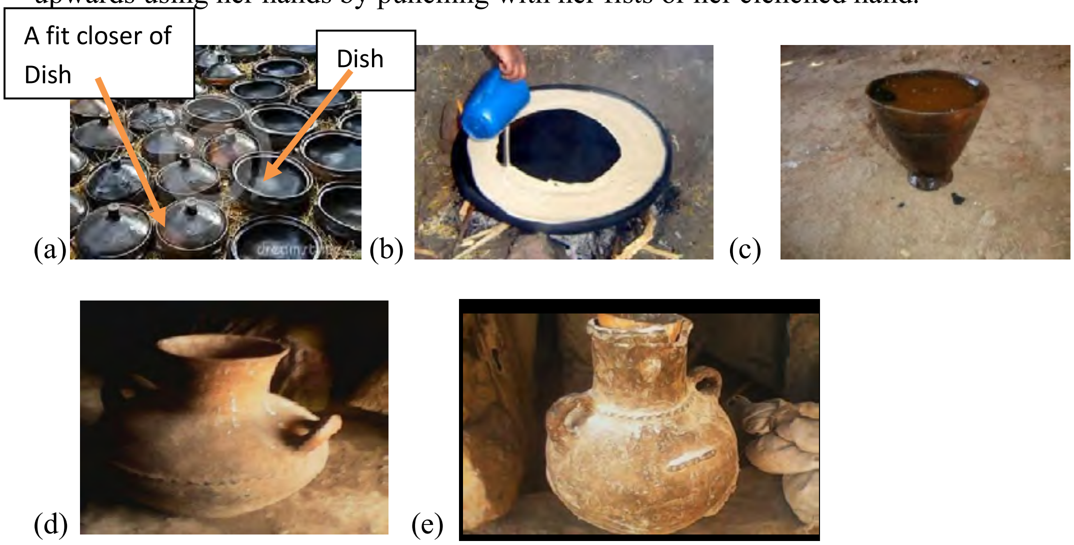


Figure 4: Products of the pottery workplace:(a) traditional dish;(b) ‘migune’ with a traditional food called ‘Injera’ is baked on it; (c) qil; (d) pot; (e) Gen

At this juncture, she was asked how she knows the limit of its depth and width or diameter while punching down to mold it and what this shape is called. To these couple of questions, she reacted as follows.

> I don’t know any other name other than disti. Its width and depth depends on the size needed. If I am ordered to make a dish that can contain one ‘tassa’ liquid, its depth should be approximately equal to the length from middle finger of stretched hand to the wrist and its width is 1½ to 2 of the length from middle finger to the thumb of stretched palm. I can change its size by making large or small only when it is wet. (Kesre, 23/12/2013).

The geometrical shape or pottery that engages the potter in activity has no special mathematical name but its functional name dish (Figure 4 (a)). Through crafting wet clay, the potter constructed a geometrical three dimensional container, the dish. The volume of the material produced is measured using hand and fingers. Since the disti looks like an upward open concave, it has depth or height and circular appearance with varying radiuses i.e. the length of the radius of a circle increases as we go from the bottom up to the opening edge. The potter also need exact measurements when making the dish’s fit closer.

Geometrical construction is more visible in the practices of the sewing craft called ‘tilf sev’ as described below. The ‘tilf sev’ artisan was asked to identify the types of ‘tilf’ and how he constructs them on the cloth. He explained as follows.

> Flower, star, leaf, biscuit, cross (+), V-shape, and butterfly are some types of tilf that I remember. For example, let me tell you the procedures of making a star picture on the cloth. First, I make a 30-by-30 larger square using a suitable colorful thread, then from each corner of this square, I make four other small squares of equal dimensions of 7-by-7 (this length of dimensions may vary from person to person). I draw this way by putting first points and then joining them to form the sides (Gulesh, 24/7/2013).

The ‘tilf’ maker first puts points by counting threads on the cloth, then joins these points to form lines that meet end to end to form sides of a square or rhombus, and then forms other squares or rhombuses at the four corners of the first figure following similar methods. To understand this, it is possible to consider drawing on a square paper. In this case, if a person wants to draw a square, he/she would count lines in any direction, then make points, then join these points to draw lines as sides of the needed figure, and this joining of points will form the required figure. Since a traditional cloth is made by weaving threads, it is analogous to a square paper containing plenty of squares formed by crossing lines i.e. woven lines.

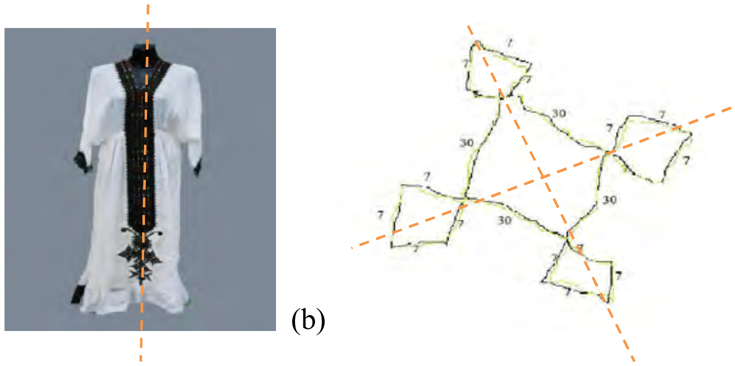
Therefore, the numbers in figure 5 (b) are number of threads in the cloth. These threads are not the ones sewed during the ‘tilf’ work but they are part of the cloth and woven when the cloth is made in the weaving process. These threads are used to put points and form or draw parallel lines of equal length. Mathematically speaking, these numbers represent the magnitude of the dimensions of the rhombuses. The lengths of the dimensions of the squares or rhombuses are known by counting the threads on the cloth without using any measuring instrument. The unit here is not centimeter or millimeter as in academic mathematics but it is expressed in terms of threads. The above discussed technique and procedures of constructing geometrical figures is similar to the Angolan sand drawings where they put points on the ground and form any shape following these points (Gerdes, 1988a).

The concept of lines and parallel lines can be also observed from the sowing season when farmers plow their farmlands. The following was taken from the informal talk with Mr. Fassika during the observation session of the plowing and sowing stage in the afternoon (2:30-4:30PM).

> Why I am plowing with some gaps at first is that I want to form 'tilm' by plowing few straight lines with some gap between them. This 'tilm' is used in order to know and identify the field with seeds from that part of the land with no seeds. After forming the 'tilm', I will hold the crop seeds in small 'qaqa' and start sowing them by my handful within the 'tilm'. When I finish plowing the field within these tilm, I will start to form other tilm, and so on (Fassika, 16/7/2013).

The parallel lines in this case are helpful to solve the problem of over-sowing or jumping an area without sowing. This construction of parallel lines on the ground is a tool that emerges during the process of accomplishing the goal oriented work activities and in solving related problems with regard to wastage of seeds or piece of land.

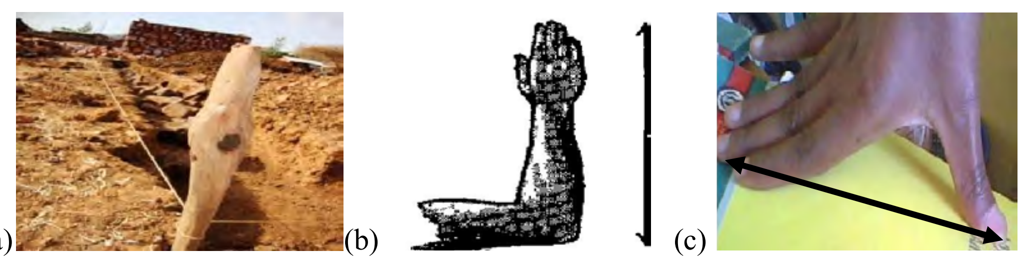
Besides geometrical construction and shapes, the concept of symmetry is there in the shapes. As Mr. Gulesh showed the sketch on the ground during the interview session and presented in figure 5 (b), the picture is symmetrical about the axis shown with broken straight line. This is for a particular picture taken from the 'tilf' of a cloth as shown in (a) of figure 5. The whole strip of crafted picture on the cloth (figure 5 (a)) is also symmetrical bilaterally. That is to say that if we fold the cloth about the vertical line running from neck to the end of the strip, the pictures in the two sides (left and right) fit together. The broken lines are inserted in both pictures to show the lines of symmetry of the 'tilf' parts. Moreover, the concepts of congruent and similar figures can be observed in figure 5. These ways of geometrical constructions and symmetry can also be found from other ethnomathematical studies in other cultures and countries (see for example, Gerdes, 1999).



(a) (b)

Figure 5: The 'Tilf' design and craft: (a) Traditional cloth of females decorated by 'tilf'; and (b) a sketch of a part of the tilf

With respect to measurement, anthropologists and researchers have investigated African practices including Ethiopia. For example, Zaslavsky (1973) in her book called 'Africa Counts: Number and Pattern in African Cultures', quoted an Ethiopian proverb related to measurement. The quote reads as "Measure ten times, tear the cloth once" (p. 89). This quote shows that indigenous Ethiopians are not careless in precision of measurements. Measurement of quantity and capacity of geometrical solids or other shapes is also a common practice in the workplaces visited.



(a) (b) (c)

Figure 6: Measurement Instruments of Length: (a) The process of laying the base of the house in the house construction workplace, (b) 'Koriz' (hand measure which is about half a meter). The picture is taken from Zaslavsky (1973), and (c) 'Tigevile' (length from thumb to middle finger of stretched hand)

Lengths of short lines are measured using some traditional instruments such as 'tigevile' or 'koriz' of body parts as given in figure 6 (c) and (b) respectively, 'kevire' (rope as shown in figure 6 (a)) and 'tsavir' (a rope like string made from leather as given in figure 7 (b)). However, beyond the length of a short line or distance, long distance between two places or villages or towns is not measured in terms of ‘tsavir’ or kilometers but in terms of the number of hours or days it takes to complete the journey. A participant was asked to tell the distance from seqota to Rubaria and from seqota to Abergele.

> I don’t know in kilometers but to reach Rubaria, it takes a car about 15-30 minutes and about 1-1½ hours if you go on foot depending on the speed of the car and the person. From Seqota to Abergele, a car reaches in 2-3 hours and a foot traveler reaches in 1-1½ days. But this increases when you travel from Abergele to Seqota because there is very large mountain to travel up (Fassil, 16/12/2013).

This shows distance traveled from place to place is computed using the time it takes. Moreover, it shows that direction of the travel influences the time taken and speed of the traveler to finish a particular distance. This shows that, in the cultural one, there is no SI unit used but approximation based on hand measures.

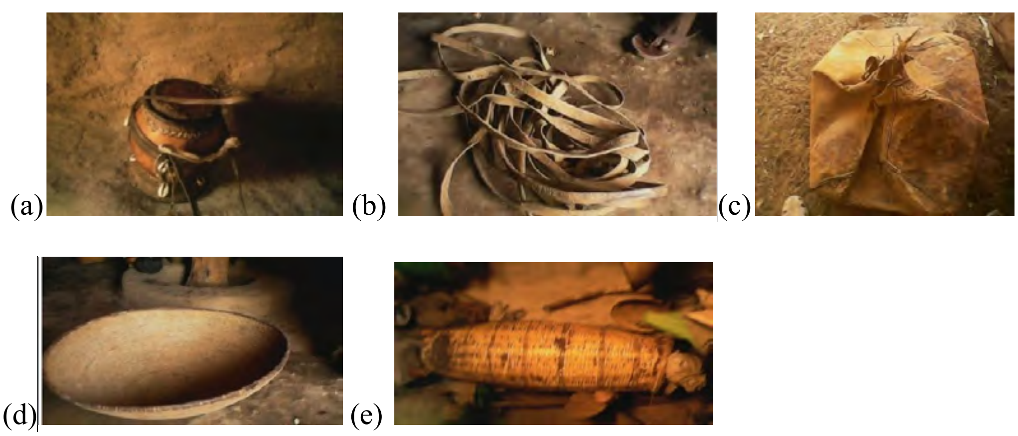


Figure 7: Traditional instruments of measurement: (a) Beshe, (b) Tsavir, (c) Ayvir, (d) qaqa or kivi, and (e) Shirfa

The instruments used also vary according the situation. For example, to measure the amount of water or milk, ‘beshe’ can be used. The ‘ayvir’, ‘qaqa’, and ‘shirfa’ of figure 7 (c), (d), and (e) respectively are used both as containers and to measure the quantity of crops and cereals. Of course, in some workplaces such as the house construction and shop related merchandises, it is possible to use SI units such as to measure lengths of dimensions of the house in order to lay the basement. For example, the following is about how the house builder solved the mismatch between the length of the dimension of the base and the instrument (a meter) used to measure this length. The conversation is between Mr. Genana and his co-workers. This interaction was recorded during the observation session of December 6, 2013. This happened when they were measuring the sides of the bas of the house to be built. In order not to miss the story's ideas, the interaction is put directly.

> Genana:We are going to lay the base of the house within this area (pointing his finger), please let's measure the 4-gon sides, stand wooden poles at each corner, and stretch this rope by joining at these poles. The house should have area of 3 ½ by 3 ½ meters. Here is the meter. Hurry! Let's begin.
>
> Co-worker:This meter has (showing the meter) I think a label showing up to 2 meters, are we going to stretch twice and measure two times for a single side?
>
> Genana: First, we put four large stones at the four temporary corners. Then we drop and stretch the meter once starting from one of these stones which means we will have two meters length, then put a mark at the end, and then drop the meter again starting from this mark and read at the label 1.5 meter. When we add 2 and 1.5 meters, it will give the total length of one side. This way we will do for the remaining three sides too, is that clear?

To lay the base of the house, they first put four big stones as temporary four corners of the house. Then, they measure the distances between any two of these marks, adjust according these lengths and stand wooden sticks at the final marks of the four permanent corners. Now, they stretch a rope that joins any two of these four sticks and to form the sides (see figure 6 (a)). The argument was raised from the mismatch between the meter's labels and the length of a side of the base of the house when the coworkers tried to measure. This is a problem emerged while the workers were trying to do their everyday practice. The problem is solved by the builder's experience of measurement and mathematical analysis. This process of laying the base of a house and measuring its sides and angles is similar to the practices of Mozambican farmers' house building processes (Gerdes, 1988b; Zhang and Zhang, 2010).

Area of a geometrical figure such as a farm land is measured in a different way compared to school measurements. It is conceptualized as the number of 'tsimir bil' (pair of oxen) that the farmland will take to plough it fully in a day. The 'tsimire' (pair) should consist of strong and young oxen to pull the plough quickly and work hard the whole day. Explaining how the area of a farmland is measured, a farmer participant described as follows.

> It depends on the weakness and strength of the oxen and the farmer because we measure the area of a farmland in terms of how many pair of oxen it takes to plough it within a day. When I come to my farmland, it takes 6 pairs of oxen to plow it in a day if the oxen are strong and it takes 10 pairs of oxen if the oxen are weak….how I know this is that I am a farmer from maturity age up to now and I used to plow on the present farm land at least for 10 years. So, I know its area, what crop is suitable for it, and other things about my farm land…..The agriculture experts sent by the government measure it and told me it has area of 60 by 80 or something like that but I don't understand and use it because I am illiterate (Abera, 20/11/2013).

According to the above quotation, although the experts tell the area of the farmland in terms of SI units measured mathematically, the farmer does not use this since he has his own ways of knowing and calculating the area. This mathematics is learnt first from trial and error and then developed through experience in a practical life long activity. The dimensions of the farmland and their lengths are not relevant here to find its area. This is a different conception of area from that of school definition. Such difference of area conception between in-and out-of-school mathematical practices is also found by Bishop (2012) in other cultural groups such as Papua New Guinea.

However, the gap between academic and everyday conception of area seems to come narrower when the region measured is a house. Unlike in the case of farmland, the dimensions of the geometrical figures are now visible and the area is expressed in terms of these dimensions in the case of house. The difference between the academic one, in this case, is on the units because farmers measure using their hands but not in meters.

Table 4: The relation of traditional and modern measurement instruments and units

S N	Name	English Description	Mathematics
Length			
1	Tigevile	Distance from thumb to middle finger	25 centimeter
2	Koriz	Distance from elbow to middle finger	50 centimeter
3	Tegire	One step	1 meter
4	Miren	Leather rope	3 meters
5	Tsavir	Leather rope	6 meters
Weight			
1	Bucheri	Cup	1/3 of kilogram
2	Merti		1 kilogram
3	Tassa		2 kilogram
4	Avile	This is a traditionally crafted from grass	2 kilogram
5	Shilicha	Traditional sack made from leather	6-10 kilograms
6	Kune	traditionally crafted from grass & thread	10 kilogram
7	Nivke		20 Kilograms
8	Mar	Traditional sack made from leather	40 kilogram
9	Kesha	Sack	50-60 kilogram
10	Ayivir	Traditional sack made from leather	80-100 kilogram
11	Kifana	Traditional store crafted from cow dung for storing crops	2-3 Ayivirs or 1 to 2 quintals
12	Shirfe	Traditional store crafted by weaving 'kerkeha'	3 Ayivit or 2½ to 3 quintals
13	Ariqe	Large hole in the ground for storing crops	>=10 Ayivit or 1000 kilograms
Volume			
1	Merti		1 liter
2	Tassa		2 merti=2 liters
3	Beshe		1-2 liters
4	Lege		4-5 liters
5	Chin	Pot	4 Tassa=8 liters
6	Gen	Pottery which is larger than a pot	7 Tassa=14 liters

Source: Compiled by the researcher

> We know the area of our house by saying a house of 6 or 7 if it is circular and a house of 5 by 6 or 7 by 8 if it is rectangular.…the numbers 5, 6, 7 and 8 indicate the number of arm measures of a moderate person (the length from elbow to middle finger).… We know the area of our farmland in terms of the number of pair of oxen that it can take to complete plowing in a day, but these days the agricultural experts tell us the areas of our farmlands in hectares (Fassil, 16/12/2013).

The idea of measuring the area of farmlands in this extract is similar to the previous one. But the addition here is how the area of a house's base is computed. The dimensions of a circular region are always expressed in terms of its diameter. Accordingly, the diameter of a circular region, hut house in this case, is used to tell the area of that figure. This is somewhat different from what academicians express area as $A = \pi r^2$ with r being half of the diameter. Another issue raised here is that the traditional mathematical practices are influenced by the academic mathematics introduced by agricultural experts.

As given in table 4, volume is measured using different instruments and expressed in terms of the capacity a given container or vessel can hold a given amount of liquid or cereal. For example, for the traditional brewer, the volume of gen or pot is understood in terms of the amount of mixture that it can hold. At the beginning stage, the 'shilla' brewer should buy crops such as sorghum, barely and corn, hop, and fire wood, and then she should know all her expenses. In doing so, she knows the proportion of each ingredient to be included in relation to the capacity of her container or kettle. For example, the 'Shilla' brewer was asked to explain the size of the kettle she has and the amount of each ingredient needed when brewing as well as the expenses.

> I don't know the exact size of a 'Gen' in terms of liters as you do in cities but my largest container takes 10 Tassa corn, 6 Tassa 'Gosh', and 6 Tassa fermented barely. If it is the small container such as pot, it will take 5 Tassa corn, 3 Tassa 'Gosh', and 3 Tassa 'buqil' (Atalelech, 12/8/2013).

In preparing the components of and making the mixture, she should know and bear in mind about the proportion of each component as well as the capacity of the container where the mixture is put. Knowing the kettle's capacity is related to the concept of volume of that geometrical solid. Other instruments used to measure the quantity or amount of crops include tassa, sacks, and donkey. The relation between them is below.

> If three 'Tassa' of 'teff' are sowed and if the season is good enough, 3 donkeys of 'teff' will be harvested…One donkey can carry two sacks of 'teff' and one sack is equivalent to 22 or 22½ 'Tassa' of 'teff' (Abera, 20/11/2013).

This extract also introduced different measurement instruments and units. To pick the crop from the 'warne' (a circular place where the crop is separated from its straw) and pour it to a sack or 'Ayvir' (figure 7 (c) and table 4), they use 'qaqa' or 'kivi' (figure 7 (d)) all made up of knitted grass and thread. To transport harvested crops from the 'warne' to home, they use 'Mar' and 'Ayvir' or sack around urban areas. Load related measurement is expressed in terms of the number of the donkeys that transport the load. Moreover, conversion factors used to convert from one to the other measurement unit is described in the above extract. Accordingly, if a farmer reports that he has harvested 6 donkeys of teff, it means he harvested 12 sacks or 6 ayvir of teff depending on the context.

Time measurement is also important mathematical practice of all workplaces because without knowing how much time it takes, a potter will not proceed making a pottery; a traditional brewer could not make alcoholic drink liked by her customers; a farmer will not plan when to sow and harvest. A 78 years old weaver, in response to the question "How do you count or know the time?" described how time counting is originated and practiced.

> By guess, looking to my shadow, and asking other persons who have a watch….First, as we have learnt from our ancestors, there is a season when the day is very long and the night is very short and vice versa. For example, in the present season which is called the x-mass sun, the day has 9 hours and the night is 15 hours. When we ask our fathers why this happens, they told us that God made this for the sake of animals because, in this autumn season, animals can get their food from near fields and need not travel long distance to get food. Likewise, the reason why the night becomes short is that animals should pass short nights chewing the food collected during the long day. During the long fasting season (February, March, April, and May) the night is short (9 hours) and the day is long which is 15 hours (Setargew, 9/12/2013)..

This extract shows that indigenous people count time using the position of their own shadow or a shadow of any thing around them with respect to the sun's position. Regarding seasons of the year, they have culturally inherited knowledge that seasons are organized by God in a way suitable to their cattle. But, how does a shadow tell the time? The priest farmer answers

> When the dark is replaced by light we call 'qishign', from the sun rise up to about 5 o'clock, it is called 'qashe', from 6 oclock up to 7 o'clocl it is called 'giriq' (lunch time), from about 8 o'clock up to 11 o'clock it is called 'kunus kunu', and when the sun sets it is 'kunu' or 'qim dilimene' (return of cattle from field to home). With regard to shadow, if I am in my farmland and want to know the time, I stand straight, look my shadow, make mark at the point where my shadow ends, then measure by counting the number of feet from the place where I stood first to the mark where the shadow ended. Six or more feet show it is still very morning around one or two o'clock. Four feet indicate the time is around 3 or 4 o'clock. When the shadow diminishes, it is time for lunch. We do similarly in the afternoon but the shadow gets longer and longer during the afternoon (Fassika, 15/7/2013).

Each portion of a day has its own name. The main point here is how they count the time. Morning and evening are simply known with reference to sun rise and sun set respectively. The problem is to know the exact time during the day. To solve this problem, they have to measure their own shadow using their feet. An important formula here is that as the length of the shadow (s) decreases, the time approaches to six or mid day and the converse is true in the afternoon. Put mathematically, it can be expressed as $\lim_{s \to 0} f(s) = 6$ or $\lim_{s \to \infty} f(s) = 12$, where time t=f(s), s=length of shadow in feet, 6 and 12 represent mid day and sun set time in local time. Besides symbolizing time using local objects and events, period is also perceived as the amount of time needed to finish a given activity. For example,

> Since we don't have time counter like what you do, I will ask my neighbors to know the exact time otherwise I use my own marks of shadow…. It takes 6-7 days to finish making a pottery. If I started making this pot in the early morning, the next morning will be the first day, the next morning will tell me the second day, and so on. This is the way I count the time in days (Shege, 13/12/2013).

Time counting is not confined to one's shadow but also by marking the shadow of big trees or mountains or house. To do so, first they ask neighbors or other persons who have time counters and then make marks using the shadow or anything around them. The next day, they just use that mark and guess the time for lunch, noon and so on. Accordingly, the potter knows when to expose the wet clay to air and when to take it to fire. Moreover, a week (6-7 days) is the period when pottery is completely produced. When the potter counts the number of days within a period of producing pottery, she starts from the time of start to make the material and counts by saying the first, second, third, and fourth day until the pottery is ripened. This shows that there is another number sense within this process of time counting. This is ordinal mathematics.

Pattern is another geometrical concept embedded in workplaces. For example, patterns exist in the house building workplace. After laying the base and Knowing the position and height of the doors and windows, the walls are built by placing one cobblestone over the other. How do these cobblestones stand one over the other to form the walls? Wouldn't they fail? The house builder explained the answer for these questions as follows.

> What do you think the use of this mud? It is prepared and used to attach and held to stones together. Besides, we have a method called 'tying' that is a method where we make two stones to carry one stone above them. This stone is called a tying stone for the two stones below it. Again this stone is tied with other two stones placed to its left and right sides by other stones above them. So, one stone might have been tied by four stones two from below and two from above it (Genana, 6/12/2013).

As can be seen in figure 8, the process of tying to held stones together leads to the formation of mathematical patterns. The work related goal here is to held stones together with a strong tie so that no stone could fail and the wall is held strong. The mathematical pattern is not intended goal but emerges as part of accomplishing the work

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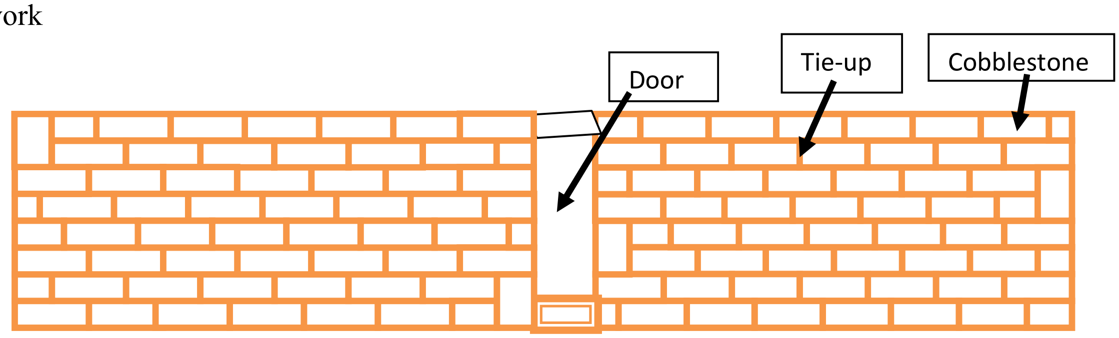

Figure 8: The faces of the walls of a house that show geometrical pattern

4.2.5. Location and Direction

Locating shows how people know their way, the position of home, traveling to some place without getting lost, relating things to each other due to their relative position (Bishop, 1988). The location of grazing field is an important prior understanding required by a herder. Determining the position of an object with respect to a given reference is part of a location finding. After laying the base, the house builder should bear in mind the limit of how high the house should be built from the base. In our case, since the house has rectangular base, four walls need to rise up to the required height.

> After laying the base, we have to determine the position of the door since we have to leave space for it while building the walls. Some times the issues related to door and windows are decided by the house owner. In our case, the employer told us that the door should be towards the West and should be 2 by 4 'qoriz' (hand measures). We are also ordered to make one window on wall to the north of the door and should be 1 ½ by 1 ½ 'qoriz'. At the edges of the house where the four walls or faces meet, we put sharp cobble stones that fit perfectly without any gap because we have to keep the 'khurnae' (angles) equal from the base up to the top. We have always measuring instruments such as rope or meter in order to check the levels frequently. These are all our duties and the ways we work (Genana, 6/12/2013).

Throughout the construction process, the builder should measure the height reached, the levels, corners, and the size of door and window openings. This continuous measuring activity helps the builder to put the windows and doors in their right position and direction, to decide when to stop building the walls, and to check with the required dimensions. Although the name is different and the unit is not exactly expressed in degrees the walls of the house should meet at right angles and form dihedral angles. So, the conception of plane and solid angles is evident here.

Direction telling is also common in out-of-school everyday life. For example, the interviewer asked the question, 'How do you know/show directions? Say for example, a guest wanted to come to your home and called in your phone and asked "where is your house?” by specifying that he is around the square (piazza). How could you tell your house’s location?’

> Ok! If he is up there around the bus station or the square (Mazoria), I would tell him as follows….Come down through the main asphalt road until you reach St. Marry Church, when you reach there, you cross the asphalt road leaving the church to your left, come through the narrow foot road and you will see my house painted in flag color with big tree in front (Setargew, 9/12/2013).

The location of a thing or place is described with reference to some familiar buildings such as churches or big trees or colored houses and so on. The flag color is to mean any of the colors in the Ethiopian flag (green in this case). Herding is also closely linked to finding direction and location of grass and river. A herder should, in the morning, know the place for grazing. Asked to explain how he identifies the direction and position of the place for grazing his cattle, a herder described as follos.

> I know from the previous day’s experience most of the time. But most of the time, neighbors and friends go to the field together… to identify the direction and place, in the morning we (friends) discuss where to take our cattle ‘kore fenizigo’ (east) or ‘kore tiwenizigo’ (west), or to ‘Zamira’ (river name), and so on. If our parents tell us where to go, we obey them (Arega, 13/11/2013).

In the morning, the herders should discuss with friends or parents about the location of grazing place and river for drinking water for their cattle. The place for grazing is chosen based on previous day’s information such as availability of grass and drinking water. This shows that the herders know the sense of direction and location.

4.3. Mathematics in the Primary School Setting

Since brief description of schools is given under the first section of this chapter, the teachers and students’ activities observed in classroom and the teachers and students’ reflections on mathematics and its relationship with everyday life are presented here. Moreover, students’ performances on contextual and plain mathematical tasks and their reflections on these tasks, as well as the findings on how textbooks use out-of-school mathematics are also the main issues analyzed and described under this section. This section is organized into five thematic subsections that are produced from cross analysis of the two school related cases. The first subsection is about views of teachers and students on the mathematics practiced in and outside school. The second subsection discusses mathematics teaching and learning viewed by the classroom practitioners. The third and fourth subsections deal with the extent of and the factors that influence using out-of-school mathematical ideas and practices in the teaching materials and classroom. The fifth and last subsection is about student participants' performances on mathematical tasks. All names that appear throughout the discussion of this section are pseudonyms.

4.3.1. Views on the Mathematics Practiced in and outside School

As reviewed in chapter two, one conception of mathematics is as the science of computing and working with numbers. Mathematics teaching is also viewed as the science of helping people to learn mathematics. According to some participants of this study, mathematics is a creation of certain community and presented in academic institutions in such a way it is suitable to young children/learners.

> I think mathematics came from the community but presented in school in such a way that it is suitable to teach and learn. But I am not sure from which community because some say Arabs and others claim Greek, America, and European societies. (Zelalem, 12/12/2013).

To this participant, it is unthinkable that his own community created mathematics. This view is also reflected in his classroom because he was observed presenting the mathematical concept (working with variables, in this case) in the classroom as they are written in the textbooks without trying to connect the topic to the real life of students. This will, as can be expected, force students memorize and use his factual notes and examples in exams and in their life career. When probed as, 'the community is using mathematics in workplaces, where do you think this mathematics come while many elder people in the community are still illiterate?' this teacher replied as,

> the local society is using mathematics but without realizing that it is mathematics and if you ask where numbers come from, they will say 'God created and gave to our ancestors' but at least I have learnt in college that the Arabs invented numbers (Zelalem, 12/12/2013).

Therefore, this teacher perceives that the local community uses mathematics in workplaces unintentionally as part of other everyday practices such as eating, clothing, plowing, and weeding. However, other participants have appreciations on how the local community uses mathematical ideas and concepts more than a schooled student can do.

> Do you know that uneducated farmers can calculate mathematical computations not less than that of the educated although their computation is mentally? That is they only don't know the mathematical symbols and written matters? But when you ask them how they calculate and get correct results, they couldn't tell any step-by-step procedure or method except saying 'I computed it!' But as I observed, most of the time they use pair wise addition proceeding from simple to complex by adding first the thousands then hundreds then tens or ones……… addition is used in problems of multiplication. For example if a person buys 12 eggs for 3 birr each, s/he doesn't do 3 times 12 is 36 birr. Instead s/he will add all the twelve 3s pair wise i.e. 3 plus 3 is 6 etc, then add the 6s as 6 plus 6 is 12, and so on (Kakhisho, 12/12/2013).

This teacher seems that he has observed the community's mathematical practices because his suggestions are similar to what are found from the workplace observations and interactions as presented in the previous section. He perceives that the indigenous community knows and uses mathematics of its own which is not symbolized and has no written scripts but mentally recorded representations and abstractions that correspond to real objects and practices. Other participants, too, supported the view that mathematics is part of everyday life of any community and is used in everyday activity.

> Without the use of mathematics, no community can develop further from the present situation. It is instrument to any type of success in life. I am saying this not because I am a mathematics teacher but you can site and observe any activity in any community. You will see no progress if they don't use mathematics (Ameha, 15/11/2013).

This teacher is trying to justify that mathematics is everywhere and used by everybody if one carefully observes the activities of human kind. It means that if the activity of humans is not observed consciously and critically, it is difficult to identify the mathematical part of the everyday activity as claimed by Smith III (2005). Another teacher also added that mathematics is used and important in life but it is not recognized as important tool for life by students at school.

> Mathematics plays important role on both mental and material growth of humans. Unfortunately, it is the most hated subject in our schools and other academic situations because qualifying on it is not immediately related to gaining a job (Alula, 18/11/2013).

According to this respondent, views and attitudes towards mathematics are directly related to business and job opportunity. However, this teacher’s reasons on the causes of these negative attitudes contradict to the fact that the problem is not on the subject mathematics but on its contents offered and the delivery methods used in schools both by the teachers and teaching materials. It is when the contents of mathematics become relevant to work and their real life that students can view mathematics has by its nature a job opportunity inherent in it. Students on the other hand have different perceptions on mathematics. Some like mathematics because it activates their mind whereas others dislike it because it has two faces that differ during learning and when in examinations. The following extract is one that describes why a student develops negative attitude towards mathematics.

> I am not that much good in mathematics. I don’t know the reason but it is difficult to understand and this is one of its natures that I don’t like….It may be useful to learn mathematics but since I don’t understand it well, its importance is not visible for me except for simple addition and subtraction. This is because we learn and study some concepts but when it is in exams, it change its face and the questions are different from what we studied which again dissatisfies our results and makes our work fruitless (Asselefech, 19/11/2013).

This means that when the student thinks he/she understood a given mathematical concept in one lesson study, it comes to them with another face in other situations. So, some students dislike the subject because they believe that it is uncatchable due to its irregular nature. The other participant liked mathematics because it is free of memorization but has difficulty on its forgettable nature if not practiced regularly.

> I can say that I am good at math since I know numbers such as 1-1000, 1-10000, 1-1000000 and can do operations on them. Among the mathematical topics I like are addition and multiplication and those I dislike are division and subtraction. Mathematics is important because to sell or buy house, we need to know numbers 1-1000000. For example, if I don't know mathematics and go to market to buy things, I wouldn't know the balance/changes to receive from the merchant and I would take whatever the merchant gives to me and I wouldn't know if he is a mischief (Kore, 13/12/2013).

The perception of mathematics in this extract is that learning and knowing mathematics saves someone from losing her/his money and properties. Moreover, knowing mathematics helps to accomplish transactional activities successfully according to this student. But, like Asselefech, there are things that this student is not comfortable in mathematics. In both cases, it seems that the hating behavior might have arisen from decontextualized and abstract presentation of mathematical concepts in the classroom. Again, this is related to the mathematics teaching and learning process.

4.3.2. Views and Practices of Mathematics Teaching and Learning

Teaching mathematics is generally described as difficult task for teachers in the schools of the research site, Wag Khimra. The reason is that students can neither work hard independently to fulfill the school requirements nor willing to attend tutorial and remedial classes designed to help them. One possible reason for not participating in tutorial classes, organized during nonschool days, is that children are supposed to help their parents in nonschool days and hours. It is when they help their parents in nonschool hours that they will be allowed to go to school. This proposition, however, needs to be studied empirically. Mr Kakhisho of School B did an action research on this problem in grade 7 students of this school and summarized his findings as follows.

> I have tried to do action research on the low achievement of grade 7 students of this school and presented my paper in a seminar held in Dessie. The results of this action research showed me that the students do not have positive attitude towards education because when I arranged tutorial classes as part of the action research and aimed to improve their achievement, they couldn't attend my tutorials and that is why they achieve lower marks (Kakhisho, 12/12/2013).

This finding tells us that teachers work hard but students do not. Although the action research is conducted in grade 7, the teacher said that it is true for all grades since he is teaching mathematics and physics in grade six, too. But why do students hate education? In an informal talk of the researcher with the director of School B regarding this issue, she explained that there are no role models to these young children. But, still this needs to be investigated empirically if it has to do with the decontextualization of school subjects.

In general, the teachers and students of the two schools have no access to read reference books, curriculum or policy documents, research publications, and other educational materials except the few textbooks. But the teachers of the second school (school B) look more exposed to seminars and workshops because all of the teachers participated in this study said that they have participated in conferences and workshops related to teaching. However, since all the teachers took at least some methodology courses in their college education, they tried to reflect on what research, curriculum or policy documents say about connecting mathematics teaching and learning to the real world.

> Although I don't have the access to such materials, from my college experience, they say that the teaching method should be student centered and participatory. All also tell that the teacher should be action researcher and problem solver (Alula, 18/11/2013).

The experience of this teacher, gained from exposure to research publications, curriculum and policy claims about mathematics teaching, is mostly related to the ability of the teacher to do classroom level research and improve his/her practices. This is in agreement with Mr Kakhisho's action research. One important point raised by both Mr. Alula and Mr. Kakhisho is that doing action research helps the teacher to know the previous experiences of the learners and take action accordingly. The action is therefore connecting the classroom mathematical concepts to the students lived experiences which may be culturally or academically gained experiences.

Moreover, Mr Alula says that he learned from such documents only about student-and teacher-centered approaches of teaching. It seems here that this teacher equates contextualization of concepts to the student-centered method of teaching. This is because the question was related to what the documents say about connecting mathematics teaching to students' real life but the teacher responded in terms of student-centered though the later includes contextualization issues. The exposure of a teacher from the other school is almost similar to this although her explanation below goes deeper than this.

> I took courses about teaching. I also participated in a seminar that trained us how to approach our students. They all say that we have to teach by considering the students level of understanding and ability. Also that we shouldn't by-pass a topic without assuring that the student understand it and if at least some students are not clear with it, we should try our best to clarify it; and so on (Neyni, 10/12/2013).

Mrs Neyni, learnt from the literature and seminars that a teacher should have the attitude of helping his/her learners. This means that knowing only types of teaching is not enough for a teacher. A teacher should, besides understanding methods of teaching, know his/her students' experiences, weaknesses and their real life problems.

The above few paragraphs show that the teacher participants were asked to reflect on their exposure to educational research publications and policy or curriculum documents as well as the gains from them. The intention of the researcher was to understand if mathematics teachers know that these documents recommend connecting school mathematics with the students' out-of-school practices. According to their reflections on this issue, the teachers were then asked to reflect on whether they accept and use the suggestions of the educational documents and seminar sessions or not.

> I accept and use some of these suggestions but not all. My view is accommodating both teacher-centered and student - centered teaching methods. This is because if I use completely teacher-centered method, students will become dependent on the teacher instead of working independently and if I employ completely student-centered, students will encounter difficulty in understanding new concepts as they have no access to reference materials or any other media, unless the teacher gives some introductory explanations and hints from his experience (Alula, 18/11/2013).

This mathematics teacher accepts some of the suggestion but with some improvements. He believes that mathematics teaching should be eclectically inclined to mixed methods to incorporate all types of students in the classroom. But he has a generalization that in student-centered teaching approach, it is freely the responsibility of the students to learn the topic and the teacher is not allowed to provide introductions, hints, and any help if necessary. This is not the right position since the literature (for example see Flores, 2010; Pang, 2005; Weimer, 2002) shows that the teacher, in a student-centered classroom, should be a facilitator and mediator rather than sitting as a simple observer and wait students to come with solutions and formulas.

Whatever, the definition and conception about student-centered approach is, there is no doubt that the learners' experience and exposure affects their learning through this method. It is because students who access TV and radio programs or books can react to topics and problems faster than those who don't have such exposure to media or books. With regard to this, Weimer (2002) advises that the teacher, who uses the student-centered method, should not use particular activity structures that are beyond the learners' abilities to handle. Such abilities are again possibly influenced by real life and academic experiences.

However, the same teacher added that student-centered teaching is helpful to pupils' learning with understanding if the mathematics topic is connected to the students' real and practical life. But, according to this teacher, this requires the teacher to know the cultural practices and values of the community from which the learners come.

> To my opinion, the right method is the student centered teaching approach that connects mathematics concepts with the learners' cultural activities. For example, in grades 1-4, the teacher should use counting models such as the abacus to teach numbers. But this requires effort and finance to prepare local objects or for the teacher to investigate the traditional practices (Alula, 18/11/2013).

According to this extract, contextualization of mathematical concepts to learners' socio-cultural life is not an easy task because it requires the teacher to invest time, effort and finance. The suggestion in this extract is also that using cultural artifacts and ideas is necessary in lower grades to teach numbers and counting. When this teacher was probed to explain if abacus is common in the local community, he suggested that it is possible to make abacus from local materials. Such locally made abacus was also observed in the pedagogical center of school B (see figure 9). The possibility of using cultural mathematical practices in teaching mathematics in higher grades such as grade five and six is, however, not visible to this participant.

Figure 9: Locally made abacus found in the pedagogical center of School B

With regard to how she implements the suggestions of research, curricular and policy documents on mathematics teaching and learning, Mrs. Neyni reflected on her practices as follows.

> Yes, I accept. And I use in my classroom because I used to review and repeat if a topic is not clear, I always try to make the topic relevant to the students background and ability although their textbook presents that topic in more complicated way… When I repeat the concept, I may use the same method as the previous explanation or new method depending on the concept. But if the topic is more difficult, I usually begin on the related concepts taught in a previous lesson, try to go from simplest concepts and give concrete examples (Neyni, 10/12/2013).

This extract dictates three main issues. The first is that when teachers participate in professional development workshops and training sessions, they tend to improve their classroom practices and try to help their students to understand the concept. The second and important theme is that a teacher is not standing in the class for only few outstanding students but should try to accommodate all types of learners in the classroom. When a teacher realizes this holistic role, he/she will start to think how to help his medium and low achieving students improve their learning. This in turn helps the teacher to find and design alternative ways of teaching and approaching the students. The third point is that considering the learners' background or experiences and levels of understanding when presenting a topic in the classroom facilitates improved pupils' learning and achievement on the subject. The issue of teacher as facilitator and relating instruction to real world is supported by other teacher as in the following example.

> …. teaching should use group discussion method e.g. one-to-five grouping system. This means we form a group of six students of which one must be clever. The teacher gives problem or activity to the group to discuss in which the clever student plays an important role to help the other members, in the mean time the teacher rounds in the class to help if there are difficulties, and then students present to the class about their group's results. So, research, policy and curriculum tell us students should do by themselves and the teacher is facilitator. I learned the types of groups (circular, horse-shoe, Jigsaw etc)

> from these research and other documents I read when I was in college (Ameha, 15/11/2013).

Therefore, the belief of the teacher about the teaching practice is directly linked with his/her experience and understanding about the particular method. This difference also indicates that if a teacher depends only on his/her college experience and do not continuously participate in professional development programs or peer discussions, he will remain without alternatives and stick to a particular approach only. It is also evident from the classroom observations that the domination of teacher-centered and decontextualized teaching approach in Mr. Alula's classroom is affected by the experience of the teacher. When we talked after classroom observations of each grade, he described this as follows.

> I used approximately 75% teacher centered and 25% learner-centered because students were encouraged to solve problems on the blackboard. I used more teacher-centered and less learner-centered because the topic is short and new to the students. Although I didn't use a balance eclectic method in my classroom, I learnt this method from my college education and I tested its successfulness when I was teaching is schools for the purpose of fulfilling practicum course. But to use or not to use this method depends on the teacher's experience and the nature of the topic (Alula, 19/11/2013).

As he approximated in terms of percentages, it is obvious that he used more of teacher centered approach. To this participant, as observed in the classroom practice, student centered teaching approach is a Socratic type of question and answer interaction between teacher and students. In the contrary, Mr Ameha explains mathematics teaching as,

> helping students use their potential individually or in groups, following flexible rules and procedures according the situation of the day, and connecting mathematical concepts with the socio-culture and other subjects (Ameha, 15/11/2013).

It seems that the difference between the two teachers with respect to their perception and practice of mathematics teaching is due to difference in experience of years of teaching. Mr. Amha taught for six years but Mr. Alula is a fresh teacher. Moreover, when Mr Alula was asked the reason why he doesn't use contextualized methods and group discussions, he explained as follows.

> As you observed my classrooms and as I told you before in percents, I did not try to use cultural objects related to the topic. But I used real life object's picture (balance) given in the textbook. This is because I am new to the area and community and hence I did not collect local objects and ideas related to mathematics. Moreover, the topic was very short to use such local things (Alula, 19/11/2013).

This indicates that he is new to the environment and doesn't know local cultural values and objects in relation to the subject. This excerpt also shows that connecting mathematical topics taught in classroom to the learners' real world is directly affected by the familiarity of the teacher with the students' culture and out-of-school practice.

Nevertheless, the concern of this study is not to compare between teaching methods and come up with one single approach as better than others. Instead the intention of the above discussions and the questions in the interviews is to examine whether teachers use every day and workplace mathematics of out of school situations to successfully teach school mathematics. More details of this issue are given in the next two subsections. But let's look at the students' opinions on this issue. Students put their observation of their mathematics classroom as follows. But, since most of the students participated in this study have similar reflections, only two extracts were taken as examples.

> The teacher first provides definitions and notes, and then he explains and then provides us problems. Students write notes and do problems and then stand in a queue to get our exercise books corrected…..Our grade 6 mathematics teacher uses some times cultural things. For example, when he teaches us about fractions, he brings circular paper and the idea of circular bread and its parts (Assefa, 19/11/2013).

The student in this extract is aware of some mathematical objects and ideas in his out-of-school community life. That is why he noticed that his teacher brought such cultural contexts and used in the classroom. The following student has similar views on how her teacher teaches but when asked how she learns and wants to learn mathematics, she reflected as follows.

> ….. he gives notes and explanations, then he works examples, then he provides us problems to be solved and seen in the classroom. I like when he groups to discuss with each other sometimes. I like most of his methods but some times he doesn't correct the exercise books for all of us due to shortage of time. So, we neither know the solutions nor correct answers because he says please correct from friends whose exercise I corrected. This makes us to pass without knowing their solutions which frustrates me when I read later. Sometimes, he draws cultural objects on the blackboard. For example, one day when our teacher taught us about equations and inequalities, he used the idea of balance by drawing it on the board in order to compare numbers (Kore, 13/12/2013).

The teaching methods are similar as the previous reflections of teachers, teacher dominated. One day instance was mentioned as the teacher using cultural artifacts such as the balance used in shops. The picture of this balance is also given in the textbook. This balance is observed in the shop workplace in order to balance the item to be sold and the standard instrument by putting them at the opposite ends of the balance. Although not regularly used by teachers, students also believe in and like learning in group discussions. However, since students are not clear with the concepts taught, they need solutions and correct answers from the teacher, they will be frustrated otherwise. One factor that caused this is the decontextualized classroom practice.

4.3.3. Incorporating Everyday Mathematical Ideas in Classroom

The extent of integrating out-of-school mathematical ideas in the mathematics teaching materials and classroom instruction is discussed here. The extent and ways that out-of-school mathematics is addressed in textbooks and how textbooks encourage teachers and students to relate the topic to everyday life are also described. To begin with, let's first introduce the numbers and their names in the local language. As presented in the translated teacher's guide and textbooks of grades one through six, the names of the numbers are in the khimtigna language. However, numbers greater than 1,000,000 have no names in that local language and are presented with their English names except the Saban script is used for writing purpose. Table 5 shows that the Khimra people have their own counting and numerical systems that are expressed in terms of words but do not have symbolic representation to each number. The history, structure, and use of this number system, however, need separate investigation which is beyond the scope of this study.

In this section, the extent to which textbooks and classroom activities use out-of-school mathematical ideas is described. To this end, the textbooks and teacher guides of grade five and six are analyzed together with teachers and students' sayings and classroom practices. To begin this discussion with whole numbers, the grade five mathematics teacher's guide advises that the teacher can begin the first subtopic of the first chapter by asking and reviewing whole numbers learnt in grade four and that this is useful to assess how much the students know and remember from previous lessons and to understand how students are motivated to learn the present lesson. This is a kind of knowing learners' background and experiences.

Table 5: Numbers in Khimtigna language

Hindu/Arabic Numerals	Khimtigna Word in the Saban alphabet	Khimtigna word in English/Latin alphabets	Hindu or Arabic Numerals	Khimtigna Word in the Saban alphabet	Khimtigna word in English alphabets
0	ባኸ/ዜሮ	Bakhe/Zero	11	ፅጭላው/ፅጭሎ	Tsich-lawu
1	ላዉ/ላወ/ሎ	Lawu/lawe	20	ለርን	Lerin
2	ሊኘ	Ligne	21	ለርንሎ	Lerin-lawu
3	ሻቈ	Shaquoe	30	ሶዉርኝን	Sowurgnin
4	ሲዘ	Size	40	ሲዝርኝን/አርቨ	Sizirgnin/aribe
5	አኰ	Akuoe	100	ላ	La
6	ዋሊጠ	Walite	101	ላዝላው/ላዝሎ	Laz-lawu/lo
7	ላንጠ	Lanite	110	ላዝፅቀ	Laz-tsiquoe
8	ሶውጠ	Sote	1000	ሽኽ	Shikh
9	ፃይጪ	Tsaich	1001	ሽኽዝላው/ሽኽዝሎ	Shikhiz-lawu
10	ፅቀ	Tsiqe	…	….	

Source: Compiled by the Researcher from the Textbooks and Teacher's Guides

Moreover, this guide book lists some teaching aids at the beginning of each chapter to be used to help the teaching learning process. In relation to encouraging teachers to use locally available objects as teaching aids for chapter one of whole numbers, for example, the grade five mathematics teacher's guide listed the following objects.

> bottle tops or similar counting objects; carefully prepared aids on fractions; cards; currency/money notes; match sticks; different tables that show place values and digits of numbers; tables that show ordering numbers; and multiplication tables (Grade 5 Teacher Guide, page 1).

Among these teaching aids, currency notes are related to everyday life. These monetary notes are directly related to out-of-school mathematical practices such as shopping but the other materials are used only to help the demonstration of fractions. For example, the fraction ½ or the decimal 0.5 can be directly connected to everyday life by showing fifty cent coin. Such demonstrations of numbers using real life objects are also common in lower grade textbooks such as the grade four textbook. Some questions related to this issue of using local models and ideas as teaching aids were also asked to teachers.

> ….Regarding their cultural background, I use contextualized problems such as in teaching division for example, I give them problems such as, "If your father brought eight caramels and wanted to divide to four of his children equally, how many caramels will each child get?", in teaching a circle, I call a word they are familiar with (eg. the ring in my finger). I also instruct students to bring models made using woods or other local materials in assignments and home works (Ameha, 15/11/2013).

This shows that the teacher participants recognize at least some form of mathematics practiced in out-of-school situations and workplaces. Contextualizing mathematics topics, to this teacher, is limited to models and problems that reflect the real world activities. Besides using real world models and objects, the textbooks also make use of everyday mathematical ideas such as measurement to some extent. For instance, in trying to introduce whole numbers greater than 1,000,000, the grade five textbook, provides activities and tasks on converting kilometers into centimeters (see activity

1.1 in page 3 and group work 1.2. in page 4 of the text). This is, to some extent, a trial to contextualize the topic with real life practices such as measurement of length. This type of practice was documented from the house builder's workplace as given in section 4.2.

However the conception and use of a particular mathematical concept is different from the school and academic one in that they have their own cultural names and approaches when problems related to this concept occur in their activities. Teachers and students compare the mathematical practices in these two situations as follows. Mr. Alula provided some details about out-of-school mathematical practices, their limitations, and its similarities with school mathematics by giving his own encounters and instances.

> The similarity between in-and out-of-school mathematics is that they both are practiced and used to solve problems, counting and calculating and measuring the size of things. Their difference is that the cultural mathematics has some limitations. For example, measurements are approximations in the cultural practices but exact in school mathematics, the concept of area is replaced by the dimensions of the figure in the cultural practice, addition is used instead of multiplication in the cultural mathematics. Irrespective of such limitations, there is mathematics in the everyday work of the local people (Alula, 18/11/2013).

In this extract, the teacher has observed that the community uses mathematics in its everyday work related activities whatever the situation and work related goal requires. Some mathematical concepts such as area, basic operations, counting, and measurement used in both in and out of school situations are mentioned here. Moreover, approximations using local materials and body parts to measure dimensions, and using local constructs for some mathematical concepts such as area are considered limitations of the out-of-school mathematics by this participant. These limitations are, however, not drawbacks for the users themselves as long as their peers and community can understand them and their job is successfully accomplished and goals achieved. These are considered limitations in the eyes of academicians and technologists who use short methods and tools to achieve more goals within short period of time. This teacher also claims that he gives corrections when students try to use their out-of-school mathematical practices in his classroom as,

> if they bring and use their everyday out of school practices in the classroom, I don't mind but I suggest them that these cultural methods have limitations and the academic methods are better and simplified (Alula, 18/11/2013).

Since this teacher believes that everyday mathematics of indigenous people has some limitations, he imposes on students to focus on the school mathematics. The researcher made some informal arguments with this participant on the saying that school mathematics is correct and indigenous mathematics is limited and finally agreed that the informal mathematical knowledge is important to base on when teaching new concepts in class. Millroy (1992) also reviewed related literature that educated people including mathematics educators believe everyday and workplace mathematics is simple and full of limitations.

From the students' point of view also, mathematics practiced by the indigenous community is a bit different from the practice of school mathematics. The following is an example of the difference in practicing mathematics.

> Sometimes they look similar but actually I think they are different most of the time because the community can traditionally add and subtract but they don't know how to add by saying 'I have one' or borrowing while subtracting except they will go around the bush even for a simple problem (Assefa, 19/11/2013).

This student tried to put his own observation on how mathematics is practiced in his community. But this difference is on the approach or procedures followed to solve a given mathematical addition or subtraction problem. The practice mentioned in this extract is also found in the views and practices of participants from workplaces discussed in previous sections. Student participants also compared the intensions of doing mathematics in and outside school as using the same subject for different purposes.

> ….in-and out-of-school mathematical practices are not similar because the mathematics in our textbooks uses addition and subtraction signs while the community uses its fingers to add and subtract numbers….the people out of school use mathematics to know the amount of money to pay when they buy food crops but not to know mathematics. However, we learn mathematics in school to know about different topics in mathematics (Kore, 13/12/2013).

The important point in this extract which is not mentioned by the teachers is that the purpose of doing mathematics in everyday workplaces is not to understand and formulate mathematical conjectures but as part and requirement of accomplishing their career related goals. However, the purpose of learning and doing mathematics in schools is to know mathematical abstractions, to proof theorems and conjectures, and to memorize facts and postulates. Moreover, this extract tells us that there is difference in symbolization and representation of mathematical concepts such as addition in that school mathematics uses signs that can be written but the indigenous community represents this in the mind, if not uses object such as fingers.

The previous paragraphs show that, according to the participants' views, there are some differences and similarities between in-and out-of-school mathematical practices in terms of their limitations and strengths, the purposes of learning and using mathematics, and the approaches followed and strategies used to solve a particular mathematical problem. How can then school mathematics be contextualized? With respect to contextualizing operations on numbers, the participants' opinions are described below. In adding and subtracting whole numbers, for example, a teacher described her experience on how students use their out of school mathematical understanding in the classroom and how she considers pupils' cultural experience as follows.

> For example, in grade 4, I usually ask problems such as ‘If you go to market with 200 birr in your pocket and buy onion for 20 birr, sapper for 25 birr, cloth for 40 birr, and spices for 15 birr, how much money do you remain with?’ I am contextualizing the problem with their everyday practices and the students understand and solve it easily…some students use their fingers or pebbles to add, subtract, or divide numbers when they solve such problems (Neyni, 10/12/2013).

According to this participant, contextualization of mathematical topics and problems begins by motivating students to speak out their experiences with similar ideas in their everyday life. This, of course, requires the teacher’s familiarity with the culture so that he/she will produce examples and problems that bring out-of-school practices to the classroom and help the learning. This extract also shows how students use their out-of-school mathematical experiences to understand classroom mathematics. It is also possible for students to use school learned mathematics in their out-of-school workplace to solve real life problems. When asked to explain and give instance when he used school learnt mathematics in his out-of-school workplace, the same student briefed as follows.

> When I look after my cattle and when my parents send me to the market or shop, I use the mathematics I learned such as adding by saying ‘I have one’, borrowing when I subtract, multiplication and counting (Assefa, 19/11/2013).

As teachers mentioned above that students use their out-of-school mathematical experiences to simplify and solve mathematical problems in classroom, this extract shows that the reverse is also true. This means that this extract is one particular example of mathematical transfer from school to workplace or out-of-school situations. According to this student, hadn’t he used these school learned mathematical concepts and procedures; he wouldn’t have solved the problem he encounters in shopping. This transfer of school mathematics to everyday workplace activities simplifies and mathematizes the indigenous mathematics what Mr Alula claimed as limited in the previous discussions. This shows that mathematical problems and ideas related to adding and subtracting are evident in the real life day to day activities of the community and that it is possible for schooled children to use mathematics learnt in classroom to simplify traditional strategies.

The teaching materials such as textbooks also address such everyday related practices of adding and subtracting whole numbers to connect the lessons to students' out-of-school experiences. For example, the grade five textbook provides problems and tasks connected to out-of-school situations such as finding the total number of people in a place, the difference between the number of men and women, the total number of kilometers of roads constructed by a construction company, the total amount of boxes of Lemons, and so on. However, these textbooks do not sometimes take the current situation of the Zone into consideration. For instance, the grade five mathematics teacher's guide suggests the teacher to use addition problems related to factory's daily production rates as related to the students' daily lives. Unfortunately, factories are not common in the zone and the students are not familiar to such production industries except for some urban children who have access to media such as ETV. This conception of contextualization equates students of Bahirdar city with plenty of factories and industries with students of Wag Khimra Zone with neither a single factory exists nor possible to watch TV broadcasts. Yet, the problem of direct translation is visible in this example.

The problem of mixing addition and multiplication approaches was raised as weakness of the workplace mathematics previously. Multiplication is not common in the out-of-school mathematical practices of people with no formal education. Repeated addition is used instead of multiplication. In relation to multiplication of whole numbers, Mr Alula provided '23x9' as an example to show the practices outside school situations.

> If an illiterate person encounters this problem, he would add 23 nine times but using the pair wise (e.g. 23 and 23 is 46, 23 and 23 is 46, and so on) method which takes more time and make the mind busy. Isn't this a limitation? In school, it is in seconds that a student can multiply if he knows the rules of multiplication. So, I am telling this difference to my students. They have to know simple ways that school mathematics provides to them (Alula, 18/11/2013).

This participant accepts the practice as mathematics but categorizes the process as having weakness for not using the appropriate strategy to solve the problem. Although it takes more time and energy, the approach is still right and the answer is the same. Anyway, one important point here is that students bring some cultural practices to classroom and use them to contextualize and understand the concept. The teacher should introduce new and scientific or simpler and alternative approaches based on this experience of the students. It is up to the students to choose which approach is important to life related work. Otherwise, this would lead students to study different approaches, one for the tests of the teacher and the other for their future life career. With regard to connecting multiplication of whole numbers with real world, the grade five teacher's guide recommends the mathematics teacher to ask first the students reflect about the relationship between addition and multiplication and give real life problems of whole numbers learnt in previous grades on multiplication. Moreover, this teacher's guide encourages the teacher to give examples that show multiplication is the same as repeated addition of the same number (Page 17).

This shows that using repeated addition instead of multiplication in real life or workplace activities is supported by textbooks and other teaching materials and recommended to teachers to use as an introduction. Therefore, teachers should not consider it as weakness of the indigenous mathematical knowledge but use it as simple and concrete form of introducing multiplication. This everyday practice is meaningful to the learners but the academic multiplication rules are not concrete though they are efficient. After introducing the academic multiplication activities using the everyday and meaningful techniques, students themselves can sense the difference in efficiency.

Fractions and decimals were also among the concepts discussed with participants. The conception and naming of fractions by the local people were discussed in relation how to contextualize classroom teaching of mathematics.

> …..When I ask a student, 'if you share one bread with your two friends equally, what part will you eat?', He will answer by saying; 'showune' Starting on this simple concept they know, I will explain other types of fractions, and so on (Neyni, 10/12/2013).

An important view and practice mentioned in the above saying is that a teacher should always start his/her lesson from what students know. To teach fractions, for example, students know the name and meaning of ½, 1/3, and ¼ from their interaction with the family and community. The lesson about mathematics should, therefore, ground on this fact so that learners can get the topic although it needs hard work and preparation. This preparation may require the teacher to involve in public discussions as part of his/her professional development. To the same question asked, the other teacher also explained as follows.

> I start from the simple fractions such as ½, 1/3, etc by asking if one full object (e.g. bread, lemon, farmland) is divided among two persons, 3 person, 4 persons, 5 persons, …., 10 persons etc, what will each person's share? They don't say directly ½, 1/3, etc but respond in terms of their culturally practiced names such as half, siso, quarter etc. Now, I tell them that the half is called one-over-two written as ½, the siso is called one-third or one over three written as 1/3, and so on. This is very helpful for me to introduce names and symbols of other fractions. I can give you examples of cultural practices of such fractions, if one clever farmer borrows a farmland from another farmer for one year, the agreement may be to take one-third of the harvested crops and give 2/3 to the owner of the farmland. Another example is when a shepherd is employed to herd goats, he will agree the 'sizne' which means to take one-fourth of the newly born goats within the year of agreement. Teaching operations (e.g. addition) on fractions such as '½+1/3' is not easy and suitable to connect with everyday life and so I use the procedures in the textbook (Kakhisho, 12/12/2013).

In this extract, also there are three important points mentioned in relation to connected teaching of mathematics. One is grounding the classroom teaching on the students out-of-school experiences. Every child in the classroom is a peasant's child and has come with some of the employment strategies as mentioned by the participant. This means each child has at least number sense including fractions. Considering this background will simplify the teachers work since students can get the topic easily. The second point is related to proceeding the teaching learning process from simple and known concrete examples to complex and abstract conceptions. The third issue is that the operation with fractions is impossible to contextualize to the pupils' cultural background. Yes! It seems unpractical to add half and one-third of a bread or lemon or farmland because they would say 'three-fourth' which is not correct according to the academic mathematical rules. But this needs the teacher to prepare well so that he/she brings relevant and real examples that suit such fractions. Textbook or teacher's guide can be among the factors that could motivate the teacher to prepare well in relation to this issue.

With regard to contextualizing fractions, the teaching materials also suggest some real objects and ways of connecting. For example, the grade five mathematics teacher's guide suggests that teachers should use out-of-school everyday examples, practices and problems in order to motivate learners to learn and participate actively in group activities. It also recommends teachers to bring and use teaching aids from the students' out of school life activities such as eating, sleeping, playing, sports, and other cultural practices. Accordingly, teachers are encouraged to ask students to connect fractions to their everyday time management like what fraction of the day (24 hours) is allocated for school, eating, play, sleeping, helping parents, doing exercise/sport, and other activities. However, in the textbooks and teacher's guides, there seems confusion on naming decimals in the indigenous language. According to the textbook, the name for any decimal number in khimtigna language is ‘tsiqant’ but the direct English translation of this term is ‘tenths’. So, 0.1, 0.023, 1.07, and other such decimals are called ‘tsiqant’ which may create confusions with tens and tenths when students join high schools where the language of instruction is English. The grade five mathematics textbook also tries to contextualize fractions and decimals to real life through the use of proportions and ratios of ingredients in traditional bread baking process which includes wheat powder, water and salt.

Measurement is also another form of mathematical practice mentioned by participants in the interview sessions.

> They (the local people) use their arms to measure dimensions which are related to geometry when they build houses; they know/count time from cock/hen (Alula, 18/11/2013).

As means of comparison between the mathematical understandings in and outside school, measurement is mentioned in the next example.

> Some look similar and some not. For example, according to our textbooks, length is measured in meter or kilometer but the community uses his hand to measure length. Volume is in liters in school and it is measured in ‘tassa’ or ‘minilik’ in out-of-school (Asselefech, 19/11/2013).

The extract shows that there are relationships between the academic and indigenous mathematics. This student is also aware of the difference between SI units and traditionally used instruments and units of measurement.

Although the teaching materials such as textbooks, do not explicitly mention the existence of algebra in the everyday workplaces or other life activities, they suggest for teachers to find such instances to be used in the classroom. The grade five mathematics teacher’s guide also encourages teachers to present real life examples and problems related to algebraic expressions, equations and inequalities to help students understand and appreciate these concepts. It also listed some local and daily life related materials as teaching aids to be used for the whole chapter of working with variables. These materials include a weighing balance, coins, and tables that contain algebraic expressions. Besides using such locally known materials as teaching aids, some mathematics teachers are aware of algebraic mathematics outside school situations.

> …. mathematical idea used in the everyday practices of the surrounding people is related to algebra. When a woman (Azeb) sees her friend/neighbor (Mulu) going to market she would send her goods to buy and bring as, "Hey my friend, please bring as half your onions for me and I will give you the money when you come back." This shows that Azeb's onions are half times Mulu's onions. (Alula, 18/11/2013).

An important conceptualization here is that although the local community doesn't use x and y variables and written equations, it is clear that there are algebraic equations and corresponding solutions in everyday workplaces solved mentally. However, when introducing algebraic expressions, teachers are not observed using such real life algebra in their classroom. For example, during the observation session, Mr. Zelalem was teaching about terms and equations of algebraic expressions in the classroom.

Mathematics

Chapter 2: Working with Variables

Variable is a letter that can be substituted with unknown number or any unknown thing.

Example: a, b, c, d, x, y, z.

1. If Alemitu can sell one egg for one birr, how much money will she get for selling 10 eggs?
2. Add twice a number and 2.

After writing the topic and its definition, the teacher wrote two word problems and asked them to students. The students hotly raised their hand on the first question and answered '10 birr' but no student raised hand in the second question. This may be because they are familiar with word problems of this kind in chapter one of whole numbers but not with the second one which is an algebraic expression. The teacher himself answered and explained this second question as follows.

> Let us say the unknown number is ‘x’. This means twice of ‘x’ is ‘2x’. Then the question tells us that we have to add this with 2, which gives ‘2x+2’. This is called an algebraic expression. Both 2x and 2 are called the terms of the algebraic expression 2x+2 (Zelalem, 13/12/2013).

Except the number 2 and the letter x, there is nothing that students know from their everyday or school experiences. They were simply writing. This type of method used in introducing a topic is usually common. The comment here is that if the teacher was well prepared, he could have used problems such as the case of Azeb and Mulu mentioned by Mr Alula in the previous discussions.

For teaching data handling, the teacher’s guide encourages teachers to facilitate their students to collect some data from their environment, summarize these data in tables and graphs, and find central tendencies of the data before the detail explanation and note presentation. The teaching aids listed to use in this chapter are coins, balls, and cards that are taken as locally recognized tools and materials students are familiar with. The statistical data given as examples and problems are related to number of local trees planted, children, age, eggs, students, and others. In this list the names are common to students and the quantity of these names is understandable if it were collected by students them selves as suggested by the teacher’s guide book. However, when teachers were asked on this issue, they reflected differently.

> How can I order such little boys and girls to collect data on the number of plants, people, or children? Who is going to give them such data? Can they count patiently every person in their village? Otherwise, the authorities will not give data for children except saying ‘arifir kinich’ (go and learn your education). It is impossible. But I can collect data myself and give them to work on it about sum, average and mean (Zelalem, 12/12/2013).

For teachers of this kind, it is impossible for students of grade five to collect primary data except going and begging authorities of the village. However, a mathematics teacher of grade six sees possibilities.

> It is possible although it is tiresome task. At least we can make students work within their family. For example, we can tell students to collect the ages of

> each family member, then find the largest and smallest of these ages. We can also tell them to write the number of goats, sheep, cows, donkey, and oxen that his/her family owns and then tell him to find the total domestic animals, find the difference between the biggest and smallest numbers of the list they have and so on. It is up to the teacher's commitment (Kakhisho, 12/12/2013).

This shows that data handling can be connected to students' lives by engaging the learners in the data collection and data processing task. This extract also shows that there is commitment difference among teachers to use available ideas and materials in order to contextualize classroom mathematical concepts.

4.3.4. Factors that Influence connecting in-and out-of-school Mathematical Practices

On the factors that affect the use of work related mathematical practices and problems in classroom mathematics teaching, the participants provided many variables. Experience of the teacher in teaching mathematics is one factor as discussed above. This experience includes familiarity with students' culture and community, number of years in teaching the same subject and grade level or cycle, and familiarity with the school and its community. The second factor, which is related to the first one, is access to culturally practiced mathematics in the community. In relation to this, Mr. Alula puts his experience as, "Since I am a fresh teacher and am new to this village, I couldn't get cultural materials and ideas related to each particular mathematics topic." To get the access to out-of-school mathematical practices and ideas, it is necessary for the teacher to interact with the local community either through participating in social events and gatherings or researching the workplaces and other culturally practiced activities. A third factor mentioned by participants is that school management do not encourage this issue in practice but in principle. Mr. Ameha explained this as follows:

> The school management is not willing to support teachers when we want to develop local models for our lessons. For example, let me tell you my experience. When I was teaching in tsana primary school last year, I asked the director to support me financially so that I can collect or construct

> mathematical models to be used as teaching aids, he refused to do so reasoning that there is no budget. If you visit the pedagogical center there, you would see nothing related to mathematics except biology pictures and geography maps drawn by former teachers and students (Ameha, 15/11/2013).

In this extract, the teacher seems to believe conclusively that cultural artifacts and ideas can only be models commercially bought from the market or made by teachers and students in the expense of money. However, finding cultural artifacts and ideas practiced in the everyday activities of the local people depends, besides the administrative factors, on the commitment of both teachers and students at the school level. It requires the teacher to work closely with the local community and participate in or at least observe their everyday activities.

The local community itself is another factor that positively influences student learning. According to Mr. Alula,

> …it is believed by the people that students learn mathematics in school and they ask everyday problems to students to help solving them. This in turn helps students to apply school learned concepts in solving everyday life problems of their society (Alula, 18/11/2013).

This tells us that when students help their parents or other people in their community in solving real life or workplace mathematical problems, they will learn from that situation in two ways. First, they will know another context for the school learned mathematical concept or procedure. Second, they will know that this concept is applicable in real life and develop motivation of studying mathematics. So, the workplaces and activities that students engage in out-of-school life is one important factor that facilitates transfer of mathematics from school situation to everyday contexts. On the other hand,

> Most of us (teachers) follow the examples and contents in the textbooks. However, only lower grade textbooks are the ones that mention related mathematical practices exist in the real world situations but when we come to higher grade levels, the textbooks present only the pure mathematics. And also, according to my opinion, it is difficult to find out-of-school example and

context for most mathematics topics in higher grade levels (Zelalem, 12/12/2013).

Still other factors identified in this extract are textbooks and mathematical topics themselves. Since teachers stick on the textbooks and most of these textbooks do not encourage connecting the topics to students real life, most teachers do not try to contextualize the contents. Moreover, the difficulty of getting real life tasks and problems for some topics is considered a negatively influencing factor to the raised issue.

4.3.5. Students' Performance and Reflections on Mathematical Tasks

In addition to general interview questions, students were asked some mathematical problems during the formal interview section. These questions were both contextualized and plain type and were asked to both grade five and six student participants since they are related to already covered topics by both grades. The contextualized problems are related to different workplaces and out-of-school practices. The plain and contextualized mathematical tasks given to the four students of the two schools are given in table 6. The works of students on the plain and Contextual mathematics tasks are summarized in Table 7 but their reflections are discussed individually.

Asselefech

In the plain set of mathematical problems, Asselefech got only one correct answer i.e. question number (a). Although there are some confusing steps, she got the correct answer of this first question. From the final answer to this question, it is possible to argue that by $40\text{-}\frac{35}{2}$, she meant (40-35)/2 which is right. In the second problem, she did the first part of the question but missed the subtraction part.

Table 6: Plain and Contextual Tasks/Problems asked to Student Participants

Plain
a) 20-(4½+6+7)=--------- b) $3\frac{1}{2} + 5\frac{1}{3} - \frac{4}{7}$= ____ c) 0.3x0.25 d) What do you call the numbers ½,1/3,1/4,1/5,1/8, and 1/10? What does your family and community call these numbers? e) $\frac{60}{12}$x20=________
Contextual
1. If your mother sent you to the shop with 20 birr to buy sugar by 4.5 birr, coffee by 6, and soap by 7 birr. What amount of money will you have to return back to your mother? 2. A farmer produced $3\frac{1}{2}$ quintals of Corn, 4 quintals of sorghum, $2\frac{1}{6}$ quintals of barely and $1\frac{1}{2}$ quintals of wheat from his four farm lands. How many quintals did this farmer produce totally? 3. A house builder wanted to find the area of the base of a rectangular house. If one side is 0.0045 kilometers and the other side measures 0.003 kilmoeters, then what is the area of the house's base? 4. What do we mean by 'showune'? Can you show this using numbers or drawing you learned in school? If we divide one bread into three, four, or five persons, what part will be each person's share? How many one-thirds are there in 15 breads? What is the 'showune' of one bread? 5. If one dozen of Lexi pens costs 60 birr, what will 20 pens together cost?

When she was asked why, she said that she can do but forgot the other part. Even in the first part, she didn't show the steps and procedures of solution process but put only the answer. When she was asked the reason for this and if she can speak aloud how the steps could be proceeded, she elaborated as follows.

> I did all the other steps in my mind. I first converted the mixed fractions into improper fractions by multiplying and adding separately. Then, to add the two fractions, I have to find common denominator which is six. This way I got the answer for the addition part. I thought it was the final answer to the problem but you told that there was a subtraction part (Asselefech, 19/11/2013).

This shows that she is comfortable with calculating mentally than writing on the paper. This is the way unschooled people do mathematics in their work (see section 4.2). This shows that out-of-school technique is used to solve school mathematical problems.

In the third problem, although the answer is not correct due to the place of the decimal point, it seems that she did multiplication of at least '3x0.25'correctly using the mental computation method. For the fourth question, she wrote only 'half' and 'one-fourth' but when she was asked to explain why, she said that she was confused with the phrases 'what do you call' and 'what does the community call'. This shows that the writing of the problem asked can negatively affect how students understand and solve a given mathematical problem. In the fifth question, she multiplied directly the numerators. She put the fraction result in the form of long division but she didn't do the simplification.

Asselefech scored better in contextual mathematics tasks (two out of five) than the plain ones (one out of five). In all the contextualized tasks, she was able to separate the context from the mathematics problem by writing number sentences i.e. mathematical statements such as multiplication or addition. The first contextualized problem is similar to the first plain task. She didn't notice this similarity until the researcher asked her to reflect about their difference.

> Are they similar? Oh! Yes! In the first, there is 20, 7, 6, and 4. In this question, too, these numbers exist. They are similar problems written differently. In this question the numbers are related to money whereas in the first question they are simply numbers and operations. The first question is about fractions but this one is about decimals and cents. It was easy for me to solve this second problem since there is no any mixed fraction to work on so that to convert into a number suitable to add but in this problem, all are whole numbers and decimals and easy to add and subtract (Asselefech, 19/11/2013).

Asselefech confirms in this reflection that context to the problem simplified the solution process in the second set of questions. Her written work also tells this because in the plain one, she was confused that '$\frac{40-35}{2}$' and '$40-\frac{35}{2}$' are equal, but in the contextualized case there was no such confusion. This is one important case where context is helpful in understanding and solving a mathematics problem using the appropriate strategy.

Asselefech did not try the second contextualized question reasoning that she couldn't read and understand the question.

> I thought it is difficult problem because I am asked to add different crops together. Moreover, I can know or guess half a quintal but it is difficult for me to find one-sixth of a quintal (Asselefech, 19/11/2013).

This extract shows a case in which contexts can also confuse students if they are used vaguely. This is because Asselefeh did not realize that the addends are quintals and she understood as if the problem asks to combine different crops in the same container. Another point is that very small fractions do not give sense when dealing with real things such as quintal. This is similar to the case some of the workplace participants discussed in previous sections ignored dividing 10 cents (0.1) into three parts as very insignificant.

In the third contextualized question, Asselefech changed the problem into mathematical statement but didn't multiply. She also knew that area is obtained by multiplying its two dimensions. When she was asked the reason why she didn't complete solving the problem, she said that "as the number of digits after the decimal point increase, I get confused how to multiply and the right position of the point (Asselefech, 19/11/2013). The way she solved the plain problem in (c) confirms this. So, it is difficult to comment, in this case, that context influenced Asselefech negatively not to solve the problem. The fourth contextualized task is where Asselefech scored the second correct answer in this set of questions. However, she didn't demonstrate using diagrams although she gave the numerical representation of 'showune' to be 1/3. This is another case to claim that students have some mathematical experience gained from everyday life and out-of-school practices.

Table 7: Written works of students as solutions to the mathematical problems

Plain tasks	Contextual tasks
Asselefech (Grade 5 student of School A)	
a) 20-(4½+6+7)=$\frac{9}{2}$+6+7=$\frac{9+12+14}{2}$=$\frac{35}{2}$ =40-$\frac{35}{2}$=$\frac{5}{2}$ b) $\frac{7}{2}+\frac{16}{3}$ $\frac{21+32}{6}$ $\frac{43}{6}$ c) 0.3x.25=7.5 d) Half,___,one-fourth, __,___,___ e) $\frac{60}{12}$x20=$\frac{1200}{12}$ 1200÷12	1. 4.5+6+7 =10.5+7 =17.5 20-17.5=20-10 10-7.5=2.5 2. 3. 0.0045x0.003 = 4. One from three, One-third, one-fourth, one-fifth 3 1÷3=0.333 5. One dozen is 12 things. 12x20=240
Assefa (Grade 6 student of School A)	
a) 20-(4½+6+7)=20- $\frac{9}{2}$+6+7 =20- $\frac{9+12+14}{2}$=$\frac{40-35}{2}$=$\frac{5}{2}$=2.5 b) 3x2+1 + 5x3+1= $\frac{7}{2}+\frac{16}{3}$ = $\frac{21+}{6}$ 32 =$\frac{53}{6}$ - $\frac{4}{7}$ =$\frac{392-}{42}$ 24 = $\frac{392-24}{42}$ = $\frac{365}{42}$ c) $\frac{3}{10}$x$\frac{25}{100}$=$\frac{75}{1000}$=0.075 d) Half, showune, one-fourth, one-fifth, one-eighth, one-tenth e) $\frac{60}{12}$x20=$\frac{1200}{12}$ =100	2. 4.5+6+7 = 17.5, 20-17.5=2.5 3. $\frac{7}{2}+\frac{13}{6}+\frac{3}{2}=\frac{43}{6}$ =7.166 7.166+4 =11.166 4. 0.0045x0.003 =4.5x3=13.5 5. Taking one part from three equal parts. It is 1/3. 1/3, ¼, 1/5 5 1/3 6. 60÷12=5 20x5=100
Kore (Grade 5 student of School B)	
a) 20-(4½+6+7)=20-$\frac{8}{2}$-6-7= b) 3 $\frac{1}{2}$ + 5 $\frac{1}{3}$ - $\frac{4}{7}$ = $\frac{6}{2}$+ $\frac{9}{3}$ = $\frac{15}{5}$ - $\frac{4}{7}$= $\frac{11}{2}$ c) 0.3x0.25=0.75 d) Giver, showune, sizine, akuant, sewutant, and stiqant e) $\frac{60}{12}$x20=5x20	1. 4.5+6+7 = 17.5, 20-17.5=2.5 2. 3 $\frac{1}{2}$ +2 $\frac{1}{6}$ +1 $\frac{1}{2}$ = $\frac{7}{2}+\frac{13}{6}+\frac{3}{2}$= 3. 0.0045x0.003 =45x3=134 =0.135 4. 1/3 1/3, t/4, 1/5 3 1/3 5. 1200
Zereay (Grade 6 student of School B)	
a) 20-(4½+6+7)=20-$\frac{9}{2}$-6-7=20-$\frac{9}{2}$-13=20-13-$\frac{9}{2}$ =7-$\frac{9}{2}$=$\frac{14-9}{2}$ =$\frac{5}{2}$ b) 3 $\frac{1}{2}$ + 5 $\frac{1}{3}$ - $\frac{4}{7}$ = $\frac{7}{2}$+ $\frac{16}{3}$ − $\frac{4}{7}$ = $\frac{7x3}{2x3}$ = $\frac{21}{6}$ += $\frac{16x2}{3x2}$ = $\frac{32}{6}$ = $\frac{32+21}{6}$ = $\frac{53}{6}$ ÷ $\frac{4}{7}$ = $\frac{49}{3}$ c) 0.3x0.25= 0.3 x 0.25 15 06 00 =0.75 d) Fractions e) $\frac{60}{12}$x20= $\frac{60}{6}$x10=10x10=100	7. 4.5+6+7 = 17.5, 20-17.5=2.5 8. 3 $\frac{1}{2}$ +4+2 $\frac{1}{6}$ +1 $\frac{1}{2}$ = $\frac{7}{2}$+4+ $\frac{13}{6}$+ $\frac{3}{2}$ = $\frac{7}{2}$+ $\frac{13}{6}$+ $\frac{3}{2}$ + 4= 9. 0.0045x0.003 0.0045 X 0.003 00135 00000 .000135 kilomete square 10. One-third, 1/3 (showed in diagram) 1/3, ¼, 1/5 3 11. 40

In the last problem, she knew the meaning of dozen but the multiplication she did was not correct. Although this problem is similar to the plain type question (e), Asselefech performed well in the plain task but not in the contextual one. When she was asked to reason out this difference, how she came to know the meaning of dozen, and why she tried to multiply the wrong numbers, she explained as follows.

> In the first one, the multiplication is given and I am required to multiply but in the second one, I have to create the multiplication by myself because everything is given in words…..When my parents buy exercise books, they buy in dozens and distribute to all brothers and sisters. I know this from them, but I made a mistake with the multiplication I wrote in the paper because I tried to multiply pens with pens instead of multiplying pens with the cost. I should have used the crisscross method that if 12 pens cost 60 birr, 20 pens should cost x birr (Asselefech, 19/11/2013).

According to this extract, the context creates an additional burden in the solving process. However, the student is finally clear with the help of context since it guides which number is to be multiplied with what. This example also shows that mathematical concepts (relations in this case) can be learned from out-of-school practices. After our discussion, she suggested one strategy to solve the problem, the crisscross method. This strategy would lead her to a similar form to the case of plain question (e).

Assefa

Assefa scored 4 correct answers out of the five plain mathematical problems. He missed the correct final answer but most of the steps were right in the solution of question two. He made a mistake on the number '392' and was surprised for this mistake of his own when he was asked to reason out for his mistake. In question (d), he couldn't list all the right local names about the given fractions except two and most of the names he listed are academic types. This doesn't mean, however, he doesn't know local names because when he discussed with the researcher during the reflection session, he reacted as follows.

> In school, they are called one-over-two, one-over-three, one-over-four, one-over-five, one-over-eight, and one-over-ten respectively. Out-side school, these are called giver (half), showune (one-third), sizine (quarter), akuant (one-fifth), timuni (one-eighth), and tsiqant (one-tenth), but when I write the answer, I didn't remember these local names (Assefa, 19/11/2013)

This list is similar to what previously discussed workplace participants called. These names and conceptions of fractions are helpful in contextualizing and teaching other fractions. Similarly, Assefa scored four out of the five contextualized mathematical problems. It was question number four which he missed in this set. Even in this problem, he missed only one out of five parts of the question i.e. the question 'how many one-thirds are there in 15?' Although he wrote '5' in the answer sheet, he corrected during the interaction with the researcher. Assefa's solution was very different from the other student participants in the third contextualized task. After detaching the context and the problem by writing the multiplication statement, he simplified it as '4.5x3' and multiplied this last sentence. When he was asked to reflect on this solution process, he described as follows.

> Since the question tells about the area of a house, it should be converted into meters by multiplying each component of the formula by 1000. After that, I multiplied this result and got the answer. Since I was running against time, I forgot to put the unit meter square at the end (Assegai, 19/11/2013).

This extract presents an important example where context guides the solution process and strategy of tackling a mathematical task. Had been the problem without any context (that is '0.0045x0.003'), this student could have multiplied directly without requiring to convert. The influence of context is clearly visible in the solution process of Aseefa to this problem.

Kore

Kore is the one who scored least in the plain mathematical problems because she didn't score any correct answer fully. However, her steps in questions (c) and (d) are better than her answers and steps in the other problems. In (c), she answered one part of the question that is multiplication but couldn't put the decimal point in its right position. She listed the local names of the fractions except for one-eighth and one-tenth in part (d). Kore's answer to question (d) shows that there is possibility for students to use their out-of-school experiences in mathematics learning and problem solving. In (d) also she divided first 60 to 12 and she tried to multiply this result with 20 although the final answer is not given. Kore was also not good reflective during the discussion with the researcher because when she is asked why or how to explain her answers, she said always ‘arqmi’ which means ‘ene enja’ in Amharic and ‘I don’t know’ in English.

Kore scored better in the contextualized problems (two out of five). Especially, although the first contextualized problem is similar to the first question in the plain set of tasks, she did correct steps and got right answer to the contextualized one. She also solved the fourth contextualized problem. This can mean that the context gave her courage to tackle the problem with the right strategy and get correct answer. When she was asked to explain why she was troubled in question two of the plain set whereas she tried the second question of the contextualized set, her response is still ‘arqmi’. She reflected on her solution to the third contextualized task as follows.

> This is how we do in the classroom. Area is calculated length times width. To do this, first, we multiply ‘45x3’, and then we count the decimal digits of one of the given numbers (Kore, 13/12/2013).

Although she was able to detach the context from the problem and write mathematical or number statement, it is difficult to conclude that context had an influence on the solution process. Moreover, she has confusions on how to multiply decimals. This issue is, of course, beyond the objective of the current study and need to be investigated in its own different topic and action. Kore was also asked to explain if she knows what dozen means and how she got the answer ‘1200.’

> Dozen means buying or selling items collectively at a time. But I am not clear why the question mentioned it. I am given in the question 60 birr and 20 pens. So, I multiplied them to get 1200 (Kore, 13/12/2013).

This is another example where context can negatively or positively influence the understanding and solution of a mathematical problem if it is not used appropriately.

The meaning of terms introduced due to contextualization need clarification. This is because Kore knows that dozen means collection of goods but not its specific quantitative equivalence i.e. a dozen contains 12 things.

Zereay

Of the five plain mathematical problems asked, Zereay scored two complete and correct answers. In the second question, he did well in most steps except mixing signs of equality and addition. This student also has confusions on subtraction and division when writing because he wrote $\frac{53}{3} \div \frac{4}{7}$ but the answer, although it is not correct, tells that he did subtraction between the numerators for the same question. He confirmed this confusion during the discussion session that he sometimes interchanges them and gets 'x' in exams. In the third problem, he multiplied everything in right steps but missed the final answer due to the position of decimal point. In the fourth question, he wrote 'fractions' as answer but during the discussion, he explained this as follows.

> We learnt these numbers as fractions in school and that is why I call them fractions. But I am not sure that the community calls them fractions. I know that ½ is called giver, 1/3 is called showune, and ¼ is called sizine but I don't know the others. When I was in grade 5, I remember that our mathematics teacher introduced 1/10 is known as tsiqant but I didn't come across this name at home or work (Zereay, 12/12/2013).

According to this extract, Zereay knows the local names for some of the given fractions but answered as 'fraction' since this is a common name to all the fractions including 1/8. He also witnesses that some mathematical teachers introduce indigenous mathematical knowledge forms to connect with school mathematics.

In the contextualized set of tasks, Zereay scored three correct answers out of five. However, it can be suggested that he has difficulties with fractions regardless of the context given in question two.

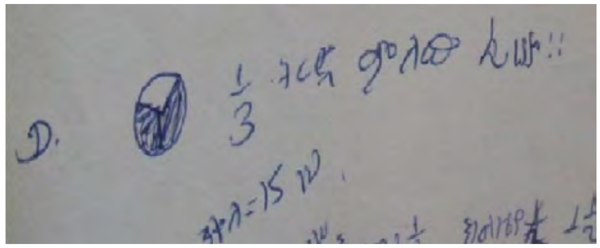

Figure 10: A student participant's diagrammatic representation for one-third

One thing observed in the solution strategies and processes of this student is that he sticks to the classroom learnt formulas and methods in all types of questions. For example, in the third contextualized problem, Zereay multiplied in a similar way as the textbooks do and he is careful to put the unit at the end. In the fourth problem, it is only Zereay who showed the demonstration for the meaning of 'showune' by drawing a circular chart and shading two out of its three parts (Figure 10). However, he didn't answer to the question 'what is one third of 1' under the same problem. In responding to this and to the fifth problem during the discussion session with the researcher, he explained as follows.

> One-third of 1 is dividing 1 into three and it is 0.3333. Since this is called repeating decimal, I had doubt how to put the exact answer to the question, which is why I left empty. For the last (fifth) question, I guessed the answer since I was in hurry but it is mistake because if 12 pens together cost 60birr, the 20 pens together should have cost higher than this (Zereay, 12/12/2013).

This extract also reveals the influence of context because the student knows how to divide 1 to 3 that gives a repeating decimal but he was not sure that such a repeating object could exist in reality. The context forced the student to realize the difference between abstract mathematics and real life mathematics. This is a case that shows some times these two mathematical practices mismatch.

In general, it is possible to claim, from the discussion of the performances of the four students in the two sets of questions, that, more or less, context influences the way students try to understand a mathematical task and the strategies they choose to solve it. At the end of the discussion, each of these four students was asked to reflect on the difference or similarity between these two sets of tasks. The responses varied. The following extract is an example of such a discussion.

> The first section contains only mathematical problems but the second is all about word problems. It was part one which is easy to solve because the words and names in part two take time to understand and solve the problem (Zereay, 12/12/2013).

This example is one indicator that students are not familiar with such contextualized tasks and practices in the classroom. On the other hand, one student responded to similar questions that he understood more in the word problems except the difficulties faced on how to add and subtract fractions. The choice of plain mathematical tasks by some students implies that they are not familiar to connected and contextualized problems in the classroom. This is one reason that many schooled people face difficulty to solve real life related problems in their career or workplace (Masingila et al, 1996).

To sum up this chapter, the data collected and analyzed in relation to the three cases is presented in this chapter. Throughout the chapter, the participants' views and practices were presented together with the researcher's interpretations. So, the overall structure and procedures of workplaces and games were described followed by uncovering of mathematical practices from workplaces and game in the first and second sections. Then, in the third section, data about the two school related cases was presented in five themes. Under this section, the teachers and students' views about out-of-school mathematics were described in relation to their classroom teaching and learning practices. Moreover, the interconnections between the mathematical activities of these two situations were analyzed from the point of views of teaching materials, teachers and students. Finally, the factors that affect these interconnections and the performances and reflections of students on mathematical problems were also presented. The information obtained from the analyses of this chapter will, therefore, be used to address the research questions of the study in the next chapter. Of course, the first and second sections together tried to address the first research question.

Based on the analyses and presentation of results in the previous sections, the major findings are summarized as follows. The first finding is related to the mathematical concepts and ideas practiced in workplaces and games. Number and number sense is used in workplaces and other activities to count money and other objects, to show increment or decrement of quantities, to compare sizes and amounts of things, to reason quantitatively, to lend and borrow things, and to think precisely and quickly. Geometrical shapes such as pots and farmlands, constructions such as in 'tilf' making, designs and symmetries such as 'tilf', and conceptions of area of a farmland are among geometry related mathematical ideas used in the workplace setting. Probability related mathematical ideas were also detected in games such as 'geveta', where the decision process of who should begin the play involves a competition called 'shakhutisheno' and causes the chance of failure and success.

The data also showed that mathematical practices arise as consequences of work related actions and interactions between peers and customers. This means that mathematical and work-related goals and activities influence one another's successful completion. This in turn implies that context influences how mathematical problems are understood, the strategy used to solve problems, and the solution to such mathematical tasks.

The other major finding is that the participants in workplaces and game settings view mathematics narrowly and name it according to the context it is used and practiced (counting or thinking) but teachers view that mathematics is a universal subject created in some where and presented in school. Moreover, there is conception difference among the teachers about the workplace and indigenous mathematics that some have doubts about its existence, some claimed it is weak and full of limitations, and some others appreciated it and suggested its possible connections with school mathematical concepts. Therefore, the data showed that it is possible to connect the classroom mathematical practices to the learners' real life by using students' experience such as cultural artifacts and ideas.

CHAPTER FIVE

DISCUSSIONS AND CONCLUSIONS

As described by the participants in the previous chapter, mathematics is used in different settings with different purposes. In out-of-school setting, mathematics is used as a tool for the purpose of achieving good production and services. This assertion can be justified from the views and practices presented in section 4.2 of the previous chapter. In academic institutions such as schools, it is used for the purpose of understanding and developing the subject itself. This is true in any community or country. But the question is that how can these two different settings and the mathematics in them be apprehended in such a way that one facilitates the other? This study partly tried to answer this question. For example, unschooled workplace participants are observed adding the number x repeatedly n-times when working with problems such as 'if one cloth costs x birr, what will n cloths cost together?' According to the teacher participants, this is considered as weakness. A student can do directly the multiplication in the above problem if he/she encounters such a problem at work. The actual data for this argument is presented in the previous chapter. This is an example that shows how school learnt mathematics simplifies and helps out-of-school and everyday mathematical practices. Similarly, workplace ideas and practices can guide learning school mathematics by providing contextual ground.

This study was intended to examine and produce descriptions of out-of-school mathematical practices and ideas in relation to their implications for school mathematics education with specific reference to primary schools. Accordingly, the following research questions were kept in mind throughout the data collection and analysis process.

1. What is the structure of the overall work-related activities of the participants in each selected workplace and game? How is mathematics embedded in such activity structures?
2. How do the goal-directed activities of the selected workplaces and their inherent mathematical activities influence one another?
3. How do in-and out-of-School mathematical practices interplay? And why do they interact in the way it is?

In the previous chapter, the participants' engagement in mathematical activities in their overall work related context was described. Since it was difficult to take out and deal only with the mathematical parts from the context in which they occurred, the overall workplace activity was comprehensively analyzed and described. In doing so, the detailed structure of the participants' practices in their workplace was presented under the first section of that chapter (chapter 4). This helped to unfold the mathematical ideas and practices inherent in the goal directed activities of the participants. Moreover, the participants' perceptions on mathematics and their performances on related mathematical tasks were described. The descriptions and analyses presented in sections 4.1 and 4.2 address the first research question of the study. That is why, in this chapter, the discussion for this first research question is combined with the discussion of the second research question.

This chapter discusses the data analyzed and described in chapter four in order to how the research questions are addressed. The chapter is, thus, organized into four sections. In the first section, research question two is addressed under the heading: action and mathematics. This will try to address two sub questions that together form bi-implication structure i.e. forward and backward implications: how does goal oriented work activity play a role for mathematical goals and practices to emerge? In addressing this question, the activity structure is briefed and this touches the first part of research question one. How does the mathematics that emerges in work related activities help to accomplish the work? Answering this question requires identifying mathematical practices in the work-related activities which is related to the second part of research question one. In both cases, it shows that the discussion of the first research question is embedded in the discussion of the second research question. In the second section, the relationship between in-and out-of-school mathematical practices is discussed under the topic ‘interplay between in-and out-of-school mathematics’ in order to address research question three. Then, in the third section, conclusions or implications are summarized. The last and fourth section is about the recommendations of the results related to the study.

5.1. Action and Mathematics

According to Millroy (1992), Naresh (2008), and Saxe (1991), mathematical problems and activities arise from the overall work related activity structure of a particular workplace. In other words, each work related goal and its action produces and needs mathematical goal and activity. That is why the heading for this section is named as ‘action and mathematics’ because action uses and produces mathematical ideas and mathematical practices also determine the action’s successfulness. According to Saxe (1991), therefore, the emergent goals (both mathematical and work-related) of action are influenced by four parameters: activity structure, prior understanding, social interactions, as well as conventions and artifacts of the work. Each is discussed below.

5.1.1. Activity Structure and Emergent Mathematical goals

The pottery workplace has a work structure of four phases. During the preparation phase, customers may come and order the material they want or the potters themselves may go to neighbors and market places and ask some people or other potters which materials are in high demand. This requires gathering information about costs of different potteries and the possible number of potters assumed to bring their potteries to the market. The motive in this stage is to get job opportunities related to their career. This motive leads the potter to do the activity of identifying potteries to be produced. If the order comes from customers, as shown in section 4.2, it is well and good or else if there is no order from customers, she must assess the demand. In each case, the work or motive related activity is accompanied with mathematical practice such as determining the cost, expenses, time and comparing between costs. This emerged mathematics again helps the decision process on the type and size of the pottery to be made.

In the second, mixing phase, soil and other necessary ingredients are made ready according to the proportion a given pottery needs, mixed, kicked by strong stick, preparing the mud for molding, and the material to be made is realized and its approximate size bore in mind. In this phase, the worker should know proportion of each ingredient for a given pottery; approximately measure or imagine the size of the container or pottery to be produced (refer to section 4.1). The mathematical ideas that this activity produces are proportion, ratio, estimation, size, and volume. Conversely, the thinking and estimations performed on these mathematical concepts influences the decision how to pour appropriate amount of each ingredient into the vessel. This again affects the activity of making the wet clay thin or thick which is again important in making the pottery.

In the third stage of making the actual pottery according to the plan in stage two, the molding is done part by part if the material designed has bending parts and large size. This activity is analogous to the concept of tessellation in academic mathematics since different geometrical shapes are fit together to form another geometrical figure. However, the observed pottery workplaces do not require such a process since dish and migune were directly made. The goal in this stage is producing the right pottery with the required size, design and beauty. To achieve this goal, the potter should keep the right shape and design planned in phase two which is geometrical thinking. Moreover, she must also remember and know the number of days or hours it takes to dry the molded material. So, the geometrical design and shape as well as construction of the pottery and the time it takes to produce are mathematical ideas produced due to the activities in this stage. These mathematical understandings are again important in the production of the right material with the required size and beauty in order to satisfy the needs of customers or buyers.

After drying, ripening and decorating the produced object, the potter should decide its cost, transport the products to markets, and negotiate costs and sell in the market. All the activities in this fourth stage require mathematical computations and ideas such as pricing, paying transport related costs, counting money, and performing arithmetic calculations during the exchange. Again without tariffing the price of the produced pottery, paying transport related fees, knowing the numerical value of the money notes, and counting money, it would be difficult for the potter to sell the product and earn the planed income with good profit.

In the 'Tilf-sev'(knitting craft), the first phase is receiving cloth and preparation by making sure that all necessary instruments and materials such as needle, 'hidyat' (colored threads), charcoal, and sometimes time scheduling. Among the mathematical tasks that emerge at this level are buying the instruments (threads and needles) and arithmetic as well as counting while negotiating with customers. These mathematical activities inherent in the workplace are requirements and tools to accomplish the goals of the work. For instance, the activity of obtaining cloths to be decorated and the service fee negotiation forces the craftsman/woman to decide on the expenses to buy materials and instruments, examine the type of design or picture to be drawn on the cloth, and decide the service fee. The expense analysis needs arithmetic computation related to money. Deciding service fees is based on the size of the cloth and the time it takes which leads arithmetic calculations of money and time.

The second and design phase is putting the agreed upon design on the cloth using charcoal or pen by using mathematical ideas such as counting. How is it possible to know the design by counting? The description given in section 4.2 can be the answer to this and other related questions. The analogy of square paper is given to clarify this issue. This counting of threads is used to know the dimensions of the figure, positioning of different figures in their right place, and measurement. In the third and fourth stages, similar mathematical practices are used including counting, arithmetic, and money.

The farming workplace has also cyclical activity structure of four phases. The first phase is related to preparing the farmland and other necessary equipments and seed corns. The softening of the soil of the farmland in this stage involves using pair of oxen to plow, and hence the concept of pair. Preparing the seed corns requires number and quantitative sense which are again related with measurement. The plowing and preparation of the corn seeds again requires knowledge about the area of the farmland. In the second stage, besides knowing the area of farmland and amount of seeds to be sown, other mathematical practices emerge. One of them is formation of parallel lines. To this end, the farmer first plow 3-4 parallel lines on the ground, then sows the seeds by spreading within the area enclosed by the parallel lines, and then starts the actual plowing process. The parallel lines are used to differentiate the part of the farmland with seeds from the other part where seeds are not sown on.

The third phase of the farming activity is related to weeding. Since the crop plants will be dominated and eaten by weeds, the farmer needs to remove the weeds on time. This takes the farmer to think about the collective practices such as libine and wufere (refer to section 4.2). So, he should borrow some amount of labor. This leads the farmer to think that he has loans and should pay later by canceling one by one. In the fourth and final stage of harvesting phase, the farmer collects crop plants to a place called 'warine', separates the straw part and the seed part, pours the crops in to a container called 'mar' or 'ayvir' by measuring using 'qaqa', and transports to home using donkeys. Measurement instruments and units are the mathematical practices that emerge from this phase and these mathematical ideas are important to know and explain the amount of crops harvested.

House building is a vast field that ranges from traditional illiterate builders to a professional architectural or civil engineer. But, in this study, only the traditional builder is considered. The builder, as other workplaces has structural stages. Salary related issues, preparing equipments such as hammer, hoe, rope, meter, and cobblestones, and time planning are among the activities in the first stage. Salary negotiation beers arithmetic of money and there is the sense of solid geometry such as rectangular prism in cobblestone producing. Laying the base by measuring the dimensions of the house and then constructing the walls of the house are activities performed in the second and third stages respectively. These activities need mathematical goals such as knowing the shape, dimensions and area of the house to be laid; accurate measurement of dimensions; understanding angles and right angles to keep the house right up; and knowledge of decimals related to the units of measurement. It is also important for the house builder to understand the relationship between units of measurement and to know the proportion of water and soil/cement while making the mud or concrete. Moreover, altitude/height of the walls and parallel lines or planes are mathematical requirements to be performed in the work-related activity determine the efficiency, precision, and successful completion of the work.

The traditional brewer's workplace is a merchandise activity where traditional alcoholic drink called 'shilla' is brewed and sold. The first phase of this workplace is making ready of the vessel called 'gen' and preparing ingredients by purchasing from the market. In doing so, she should know the size of the vessel and then purchase things accordingly. Expense calculation in purchasing crops and cereals as well as money related arithmetic during the purchasing and knowing the capacity of the kettle are the mathematical practices performed at this stage. The second phase is the process of making the 'shilla' by preparing mash and then mixing it with water and 'digo', which are the major components. Knowing the time intervals each step takes and understanding the proportion of malt, hope and water in the 'malute' (mash) are among mathematical ideas that emerge and also facilitate this stage. The third and final stage is selling the 'shilla' when customers come to the house of 'shilla'. Mathematical goals that emere at this stage include measuring using 'qil', arithmetic, counting and number sense related to selling and money. These mathematical practices are important to accomplish the selling activity efficiently and timely.

The shop based retailing merchandise and the shoeshine workplace considered in this study have similar structures and phases as Saxe (1991) described the street selling merchandise of Brazilian children. In the preparation to purchase phase, the shop owner and shoe polisher analyze on the questions such as what items are fully sold or used, which items are liked by most/many customers, how much money should be spent to buy these used or sold items, and where can these items be found? Answering these questions requires arithmetic, money, direction or location, and quantitative reasoning. The purchasing stage is going to a specific market or store and buying items in wholesale form and transporting to the shop. The mathematical goals that emerge and used in this stage are monetary related counting and arithmetic. The third phase of the structure is preparation to sell and includes activities such as deciding on prices of each item to be retailed. This decision process involves attaching numerical value to each piece of an item to be sold. This leads the shop owner or shoe polisher to calculate the difference between the price attached and the expense spent during the purchasing activity. The selling phase is the final stage which involves advertising and retailing/selling by the decided price when customers visit the shop or the shoe polisher's workplace. Mathematical tasks in this final stage of the shop and shoeshine workplaces are exchange of money, calculation of profit and Value Added Tax (VAT) related problems, and counting money and goods.

The weaving workplace is another type of workplace investigated in this study. It includes some steps and procedures to accomplish. The first step is purchasing cotton and removing its seeds and other impurities which engage the practitioners on mathematical activities such as counting and arithmetic while purchasing. The next activity is forming 'kelem' (bobbin) and purchasing and processing the 'ziha' (yarn threads). In the next activity, the weaver threads the 'ziha' (yarn threads) through the loom to form a series of parallel threads and then starts weaving by feeding the filling threads from the side of the loom by bobbins. The final activity is submitting the produced cloth to the customer who ordered it or taking it and selling in the market. Mathematical ideas emerged and used in these activities include transaction related counting and arithmetic, the concept of cylinders (the bobbins), and temporal thinking.

The two games examined are called ‘tirga’ and ‘geveta’ which have their own unique structures and rules. Both games have stages such as deciding the beginner, playing turn by turn, and determining the winner. However, they have different objectives and activities at each stage. In the first stage of deciding the beginner, for example, the tirga game involves measurement and ordinal number related mathematical activities but the geveta game has probability related concept. Without measuring and determining the turn taking queue, the playing wouldn’t proceed in the tirga game. Similarly, without determining the turn taking queue in the activity of ‘shakhutsheno’ and probabilistic mathematical reasoning, the geveta player cannot begin the game. This shows the activity structure and the mathematics inherent in it interplay to one another’s successfulness.

5.1.2. Social Interactions and Emergent Mathematical Goals

Potters make different social interactions in different stages of the work related activities. In the first stage, the interaction is with customers and peers where they exchange information on the type and cost of the pottery to be produced. This interaction leads to emergent mathematical activities such as determining the shape and size of the material as well as arithmetic in deciding on the cost. In the subsequent phases, potters socially interact with family members in labor division and with customers or buyers when selling in markets. All these social interactions and relationships between the participant/potter and customers or peers or family members cause mathematical activities and goals to emerge and phase-out. For example, in discussing with family members, the direction, location and distance of the ‘arifitse’ where the relevant soil is fetched should be known. In the interaction with customers when selling, monetary related arithmetic and counting arises. For example, after finishing making a particular pottery, the potter should decide on the price of that pottery realizing the expenses made (including the transportation costs to the market) and the profit intended. Let's look at the following conversation to illustrate this. The researcher observed Mrs. Shege in the afternoon of December 13/2013 selling her products in the Market located in Seqota town. Although there were many buyers visiting and going without buying, the following conversation was taken as important scenario for the case.

> Buyer: I want to buy this 'disti' (raising and seeing one of the dishes). How much will you sell?
> Shege: My potteries are known because they are strong enough, you can observe. If you want that dish, it is larger than the others and it costs 24 birr.
> Buyer: This is too expensive. Will you lessen some before I go to other sellers?
> Shege: If you are true buyer, you can take it for 22 birr. This is its minimum cost.
> Buyer: Let me pay 18 birr
> Shege: No.
> Buyer: What about 19 birr?
> Shege: No. but since you seem true buyer, you can pay 20 birr.
> Buyer: Ok, rather than I travel around to other sellers, let me pay. But I am sure I can get similar dish for 18 birr (giving a 50 birr note).
> Shege: Don't you have 20 birr? I don't have the change for the 50 birr.
> Buyer: Oh! Wait, I will go to that shop and buy soap to get changes (run out).
> Buyer: (returns back with 4 ten birr notes in her hand) here is your 20 birr.
> Shege: Thank you. You will see how strong the dish is and be my customer.

This extract shows that while the buyer must add some amount of money to reach the price tariffed by the seller, Mrs. Shege (as a seller) should make subtractions from the originally claimed tariff in order to agree with the buyer and sell. This arithmetic activity of raising and lessening is important deal that facilitates the two parties to agree on the deal. When the negotiation is successfully achieved, the next task is giving and taking money.

The social interactions in the ‘Tilf sira’ workplace are between the craft artisan and customers throughout the activity and sometimes with peers as well as shopkeepers when buying the colored threads called ‘hidiyat’. The interaction while negotiating on costs of the materials leads both to engage in mathematical computation and reasoning. This mathematical reasoning and calculation causes the negotiation to end with agreement and hence the activity is said to be successfully accomplished. Moreover, the design of the picture to be crafted on the cloth comes out from the discussion between the crafter and the customer.

In the farming workplace, the social interactions occur between the farmer and peers or family members or sometimes with merchants/sellers in markets when buying farm instruments or seed corns. These interactions are causes for the appearing and disappearing of mathematical problems. For example, when a farmer discusses with his family members on the issue of ‘wufere’ or ‘libne’, he will solve mathematical problems such as how many persons should be called so that the task (may be plowing or weeding) should be completed in a short period of time, what will be the expense for the accommodation of all these people at least for lunch or dinner, and how to pay back the labor borrowed in a ‘libine’ in order to cancel loans. Without discussing on these issues and the mathematical problems in them, the farmer will not organize wufere or libine for a particular phase or activity.

Mathematical tasks performed by people in workplaces have also important roles for social interactions to occur and completion of work. For example, at the end of his employment year, a herder will count all the cattle he has at the present time and compare this amount with the amount he had at the beginning of the employment year. Then he/she calculates the difference to find the excess and should divide this excess number into three or four according the agreement he had made with the employer. Finally, he/she discusses with the employer to get his/her share according the agreement by providing mathematical explanations.

The three workplaces traditional brewing, shop owner and shoe polishing are all merchandise related jobs. All involve doing emergent mathematics related to interactions with their respective customers and peers. They interact with wholesalers in the market when buying goods, crops, and ink. This engages them in counting money, computing additions and difference, and quantitative communication. They discuss with peers on retail cost determination which is again accompanied with counting, arithmetic, and retail ratios. Finally, in the selling stage, they interact with customers when selling their goods and giving services in bargaining about retail ratios, the amount to be paid, and the changes to be given.

Traditional cloth weavers make important social interactions throughout their goal-directed work structure. At the beginning, the weaver interacts with customers or with his wife while processing cotton and 'ziha' to produce threads and bobbins. This interaction gives rise to mathematical activities such as counting the bobbins, negotiating on the service fee, and time to finish the job. At the end of the work, the weaver should sell the produced cloth and hence price should be attached to the cloths and negotiated with buyers, which again leads to mathematical computations.

Obviously, games involve social interactions among the players participating in a particular game. In both the 'tirga' and 'geveta' games, the first rule of each game forces the players to determine the first turn taker or beginner of the game. To this end, the interaction of 'tirga' players leads to measurement and counting related mathematics where as the discussion between the 'geveta' players causes each player to think about his/her chance of wining the first place in the queue. In the play, both games still have social interactions that lead to mathematical activities such as counting and mental computations.

5.1.3. The Role of Practice-Linked Conventions and Cultural Artifacts on the Emergence of Mathematical Goals and activities

According to Saxe (2002), artifacts are human constructions in the form of materials and symbolic forms that facilitate daily lives. Different conventions and artifacts within the workplaces also facilitate the creation and completion of emergent mathematical activities which again help the successful completion of the work. The different currency forms are artifacts used in all workplaces and they facilitate for the emergence and performing of mathematical activities such as counting, arithmetic operations, and quantitative number sense. Calculations with monetary units help practitioners to accomplish mathematical tasks and related goals with quicker and precise manner. Price ratios are conventions that determine the occurrence and successful completion of mathematical tasks in workplaces. This price ratio is related to selling pottery with lesser prices in neighboring customers than in markets by considering transportation and other costs. Such convention leads the potter to emergent mathematical goals such as calculating the difference between the prices in markets and when it is sold for nearby customers without transportation expenses.

In the case of 'tilf' artisan, the cultural artifacts such as the different designs of pictures and instruments such as needle and 'hidyat' are important in the activity of putting the right figure with the right pattern and positioning. These artifacts are always preceded or followed by emerging mathematical goals such as imagining the picture's design and constructing the dimensions of the figure by applying counting.

In addition to currency related artifacts, the 'sizine' (one out of four) or 'showune' (one out of three) agreements between employer and employee are conventions that require mathematical computations in the farming and herding workplaces. Similarly, artifacts such as money notes and conventions such as price ratios influence the emergence and phase-out of mathematical tasks and goals in the merchandise workplaces.

In games, social conventions such as determining the first player or beginner of the game and practice linked artifacts such as sand grains and small holes are used to facilitate the play. All the rules of the game are considered as social conventions and artifacts specific to the particular game's cultural practices. These in-action artifacts and conventions are always accompanied with mathematical problem solving activities such as counting, measurement, and chance. The decisions about the beginner player or the winner are consequences of such artifacts and rules as well as the mathematics emerged in the activity.

5.1.4. The Role of Prior Understandings to Emergent goals

According to Saxe (1991), "the prior understandings that individuals bring to bear on cultural practices both constrain and enable the goals they construct in practices" (p. 18). This is to mean that practitioners in workplaces and participants in games need to have experience about the rules and procedures of the activities in the particular setting. Potters bring many different prior understandings to their work related activities. One understanding is about the type, name, and shape of the pottery so that if they do so, they will have the confidence and ability to deal with customers and their varied needs. Another prior knowledge is about the ingredients and time it takes to make a certain type and size of pottery. Moreover, they should have prior understanding about the financial, temporal, and energy expense as well as the cost of each pottery which will help again to negotiate with customers. Finally, potters need to have prior mathematical understandings in order to perform emergent mathematical tasks successfully. Both of the two potters participated in this study used mathematics learnt from elders and experience and not school learnt mathematics.

Similarly, the ‘Tilf sev’ artisans also have their own prior understandings for the work. The design and shape of the picture to be drawn on the cloth is one of the experiences that the practitioners of this workplace need to have in order to negotiate with customers. The prices of the different colored threads are the other experiences that the ‘tilf sev’ artisan needs to have when dealing with customers. School learned mathematical experience also helped the ‘tilf’ craftsman in designing and measuring the dimensions of the figures crafted on the cloth.

In the farming workplace, some of the prior understandings are knowledge about the seasons of the year, the area of a farmland, and the amount and type of crop seeds needed for a certain farmland in a given season. All these experiences have mathematical knowledge such as measurement, time, and concept of area embedded in them. Moreover; the cultural rules of ‘wufere’ (usually engaging more than two participants) and ‘livine’ (usually agreement between two farmers) are also important prior understandings that engage farmers in mathematical thinking such as negative numbers. A herder should have prior experiences such as the ways and potentials of mating animals so that to increase the number of cattle and the cultural conventions and rules of employment that involve mathematical concepts such as fractions.

The house builder’s prior understandings are related to knowledge about daily wage of house builders in different locations, measurement scales, designs of houses, cobblestones, and how to tie cobblestones when constructing the house. These experiences facilitate mathematical goals to emerge and help the activity. For example, the knowledge about daily wage helps in the negotiation of salary with the employer. Experiences related to measurement help to measure and know different lengths and dimensions of the house's base as well as angles and right angles. Prior understanding about how to tie cobblestones while building the house facilitates mathematical patterns to appear.

There are also prior understandings in the merchandise workplaces. The traditional brewer's prior experiences are related to time management, type and amount of crops and hop used for this purpose, and mathematical proportion of ingredients. The shop keeper's prior knowledge is concerned with how and where to find and purchase wholesales, how to retail, and mathematical knowledge for VAT and other calculation. The shoe polisher's experiences are similar to the experience of the shop owner but in the former one, a special understanding is required to retail a given ink/paint in how many shoes and with what amount of profit.

Prior experiences in games include knowledge about the rules of turn taking, rules of determining the beginner, procedures of the games, and the winning tricks. For example, in the process of determining the beginner player in the geveta game called 'shakhutsheno', if a player stretches his fingers outside the event set $\{w,x,y,z\}$, this shows that the player has missed prior understanding about the rules and conventions of the game. This might lead to disqualifying out from the play.

To sum up this section, the discussion above showed that there is an interaction between the work-related activities and mathematical ideas inherent in them. In other words, mathematical goals emerge while the planned work-related actions are performed. Emergent mathematical goals are different from the broader work related goals in that the later goals are intended and planned at earlier stages of the work structure and they are directions what to produce and where to reach. However, mathematical emergent goals are unplanned and emerge at any phase of the work structure for the purpose of solving problems that encounter in the way of the activity and are tools to help the completion of the broader goals. So, in the above discussion, the emergent mathematical goals are discussed with respect to the Saxe's (1991) activity structure.

Therefore, the activity structure of the emergent mathematical tasks, social interactions of practitioners with their peers and customers, artifacts and conventions that exist within the work related activity, and prior understandings that practitioners bring to work are the four parameters that unlock the interaction between goal-directed work and mathematical activities. Moreover, these parameters show that solving mathematical tasks and perfection in mathematics are practice and goal dependent.

5.2. Interaction between In- and out-of-school mathematics

In this section, the connections of mathematical practices in and out of school are discussed based on the findings analyzed in chapter four above. To this end, the second and third components of Saxe's (1991) three component framework are used. Two basic questions are asked and addressed here. The first question is: to what extent and how is school mathematics used in everyday workplaces and other out-of-school activities? This question is addressed using the data obtained from workplace participants who have school educational background, from the perceptions and reflections of teachers and students in schools, and from the findings of the performances and reflections on the contextualized mathematics tasks given in the formal interview sessions. The second component of Saxe's (1991) frame work named 'form-function shift' is used to address this question.

The second question reads as: to what extent is out-of-school and workplace mathematics used in the school mathematical practices and how do the teaching and learning of school mathematics connect/contextualize classroom mathematics to students' out-of-school lives? The interviews made with students and teachers, classroom observations, and document analyses of textbooks described in section 4.3 will help to address this question. Moreover, the third component of Saxe's (1991) framework is used to ease the discussion here.

5.2.1. School Learnt Mathematics in Everyday Real-Life Activities

As described in chapter four, the mathematics embedded in workplaces and game activities can be characterized as firmly linked to the work specific understanding and experiences of the practitioners. For example, when some participants were asked plain mathematical problems to tackle, they claimed that such necked numbers are meaningless to them and refused to solve. Another encounter was that participants from workplaces who are without formal education considered that mathematics is all about counting and thinking. All these show that the out-of-school mathematics is understood and computed with respect to the specific work context. Moreover, some participants such as the house builder and shoeshine workers were observed integrating school learnt mathematical ideas and techniques to their work specific problems and activities. This subsection, therefore, discusses such integration in workplaces.

According to Masingila, Davidenko and Prus-Wisniowska (1996), there are at least two goals for classroom mathematics teaching. The first goal is to prepare students to deal with realistic or abstract/fictional novel problems. The second goal is to help students acquire the concepts and skills useful to solve routine dilemmas encountered in life. Although the first objective is stated in all topics of the textbooks clearly, the second is not explicitly put either in syllabus lists of aims or in specific objectives of the units/topics dealt in the textbooks analyzed for the purpose of this study. This ignorance of textbooks leads teachers to avoid such an objective in their mathematics classroom lessons. However, workplace practitioners who have educational background make use of school learnt mathematics. The craftsman, Mr. Gulesh, witnesses this argument as follows:

> … let me tell you the procedures of making a star picture on the cloth. First, I make a 30-by-30 larger square using a suitable colorful thread, then from each corner of this square, I make four other small squares of equal dimensions of 7-by-7. I think you noticed many different mathematical ideas in this procedure such as counting, lines, squares, and so on. I noticed these because I learnt them in my school mathematics but even those illiterate people who work tilf sev can make them on the cloth although they don't know their names and mathematical definitions (Gulesh, 24/7/2013).

This shows that people who have school background use mathematical concepts and procedures learnt in school to achieve their work related goals. Indigenous people call any parallelogram as 'size gabu' (four faced) but this participant differentiated among the various types of parallelograms such as square and other geometrical figures such as line. This is application of school learnt mathematical knowledge in everyday workplaces. Moreover, the house builder reads the numbers on the scale of a meter when measuring dimensions of the house to be constructed. He knows the relationship between the different units of a meter. For example,

> Interviewer: What number represents half a meter?
> Genana: 50
> Interviewer: 50 what?
> Genana: centimeter.
> Interviewer: How many meters does 300 centimeters represent on the instrument?
> Genana: 3 meters.

The house builder uses school mathematics in order to convert larger units into smaller units and vice versa. It is not common to measure using the meter scale in the locality but since this person has experience of school related mathematics either from his basic education program or from interaction with peers, he can identify and apply in work the different units of length measurement. Similar argument holds true for the shop owner in the merchandise workplace because he uses a weighing balance and a meter in his shop to weigh items such as sugar or salt and measure lengths of rope using a meter when retailing during the selling phase. To sell any amount of item according the needs of his customers, he should know the relationship between grams and kilograms, centimeters and meters, and milliliters and liters. All these are school experiences. Moreover, although it is learnt from friends and experience, he can calculate percentages related to tax and discount which are school taught mathematical concepts (refer to chapter four).

The shoeshine practitioner also uses school learnt mathematics in his work related activities. He explains about how he uses school learnt mathematics in work.

> …Before entering school, I learnt counting from my family and friends. After attending school, I learnt the symbols of number and how to calculate/operate them using paper and pencil or mind. When I face with problems that involve coins, I use decimal points to add or multiply such money that include cents (Shuwaye, 9/7/2013).

Since multiplication is not a common practice in traditional workplace, indigenous people use repeated addition to solve multiplication related problems. But this participant says that he uses school learnt multiplication rules to solve money related problems encountered in work. This extract also shows that the shoe polisher uses decimal notations to solve real life money related problems. The use of numerals and symbols to record and compute on papers is a school experience of mathematics applied in out-of-school situations. Borrowing when subtracting and saying ‘I have one’ when adding numbers are some procedural school experiences of mathematics practiced in workplaces. Here is an example of this kind mentioned by the grade six student of School A: “When I look after my cattle and when my parents send me to the market/shop, I use the mathematics I learned such as adding by saying 'I have one', by borrowing when I subtract, and multiplication …" (Assefa, 19/11/2013) This shows that when students are out of school and help their relatives, they use school learnt mathematics to solve problems encountered at work. The concept of decimals used by the shop keeper and shoeshine guys in their workplaces is also school learnt mathematical practice. As one of the factors that affect applying school mathematics in real life problems, teachers mentioned that when parents ask their children to help in solving mathematical problems, children use their school learnt concepts and procedures to tackle with their parent's mathematical task in real life.

Given the above description of integrating school learnt mathematics to workplace mathematics related activities, what cognitive development is there? How do shifts from cultural form to cognitive function occur in workplace mathematics? To address these questions, using component two of Saxe's (1991) framework is essential. This component of Saxe's (1991) framework focuses on "the cultural forms that are linked to practice participation and the interplay between these forms and cognitive functions which these forms come to serve." (p. 19). This means that the conceptualization of cognitive (especially those related to mathematics) developmental processes draws on the historical development of symbols and numbers in cultural practices. Put in other words, the mathematics related cultural forms such as number and currency systems are historically and culturally constructed by the people practicing them. These forms become cognitive forms when they function as counting and arithmetic techniques and used by workplace practitioners to accomplish work-related activities and goals (Saxe, 1991).

The data for the current study showed that the cultural forms and conventions that exist in the workplaces and games visited include the use of currency system, school learnt mathematical ideas and techniques, and transaction related negotiation. To begin the elaboration with the crafting workplaces, the potters and 'tile' makers negotiate with their customers on selling and dealing with service fees. The customer cannot go to the crafter and order simply whatever service he/she needed but he/she should make a deal. Again, the potter or 'tilf' maker will no produce the product, go to customer's house to give the product and receive money in exchange. This shows that the potter or artisan and the customer should come together and deal on the issue of selling and buying or service and service fees. The same is true for other merchandize related workplaces such as shop, 'shilla' house, shoeshine, house construction, and weaving. This requires cultural form called negotiation.

This negotiation is historically developed cultural form practiced in business transaction and other traditional activities of the people. This negotiation activity drives the two negotiators' capacity and potential of convincing the other side. This convincing ability is the cognitive function emerged from the interaction. For example, when a potter negotiates with her customer, she tells the different expenses and the difficulties that she faces during the production of the pottery. This includes the time consumed, total expenses which is arithmetic, distance traveled when fetching raw materials, and the energy consumed.

In games, however, such negotiation may not work. The rules of the game are the cultural forms that shift to cognitive forms when applied in the play. The rule in the 'tirga' game, for example, claims that the game has turn taking structure and the beginner of the game should be determined first. The cognitive function developed from this rule is comparing between distances of the players' zippers from the small hole. This new form or rule orders that the player who owns the zipper with shortest distance begins the game. So, the cognitive development of comparison between size and magnitudes of numbers occurred due to the game-specific-cultural form of the first rule.

Another form-function shift in workplaces occurs in relation to monetary activities. The culturally and historically established form is related to currency system and money notes. Out of work, money serves for many different functions such as buying cattle, cloths and other life necessities. At work, this function shifts to other forms such as to count and compute arithmetical related activities that emerge during the course of the activity such as selling stages of potters, traditional brewers and weavers. These new forms are what Saxe (1991) calls cognitive functions. Moreover, workplaces such as pottery and 'tilf' making, house building and weaving need design related activities where the designs (cultural forms) take cognitive forms in the course of the activity. For example, on top of negotiating and agreeing on the cost and service fee related issues, the potter, 'tilf' maker, and house builder should agree with the respective customer or employer on the design of the pottery, picture and house respectively. Moreover, the negotiation includes the quality of the material produced and the quality of work done in the case of house building and 'tilf'knitting activity.

In the case of the pottery making workplace, the potter should think on how to realize the required type of pottery with the needed size and shape while constructing which is important to accomplish cognitive functions. The 'tilf' maker also receives proposals from the customer about the pictures and design to be used. If the design is, for example, making a picture of star called 'meskel', to put this design on the cloth, she should learn or think how to form lines, measure dimensions and lengths, and worry about the symmetry of the picture. So, the cognitive function here becomes the counting of threads to put point, the construction of parallel and equal lines, the formation of squares and rhombuses and keeping a particular meskel in symmetry with others on the other side of the cloth. In the case of the house builder, the agreement and hence the work specific cultural form is to build a house of rectangular base. But when the construction is going on, the builder has to lay the house's base and build the walls. This requires the builder to measure dimensions of the base, join perpendicular lines, and think about the height of the house and the positions of the doors and windows. This is a cognitive function of the design (cultural form).

Moreover, school learnt mathematical ideas can change their form when they are used in work-related activities. One participant from the 'tilf sev' workplace, the house builder, a farmer, and one weaver, and shoeshine persons participated in this study have educational background from schooling. The mathematical experiences of these participants gained from school shifted to another form such as to accomplish work-related goals and activities. For example, the 'tilf' artisan uses school learnt geometrical shapes and concepts to make beautiful and decorative pictures on the cloth. This is a form-function shift from pure mathematical knowledge to utilizing it in real life activities and problems.

5.2.2. Connecting School Mathematics to Real-Life Situations

To connect school mathematics to real world situations requires simulation of different out-of-school phenomena and aspects. The important aspects of real life situations to be considered in simulations of real life practices to make connection are events, questions, information/data, presentation, solution strategies, circumstances, solution requirements, and purpose (Palm, 2006). These issues are similar to the main goals of mathematics classroom activities viz. to prepare students to tackle novel problems and to help acquire concepts and skills useful to solve their future career problems (Masingila, Davidenko and Prus-Wisniowska, 1996).

According to the data presented in section 4.3, the common classroom activities of students and teachers in the observed classrooms can be summarized in five-phase structure as follows: (1) teacher enters classroom and writes topic and notes on the blackboard and students write the notes in their exercise book; (2) then the teacher explains about the notes, gives examples, asks oral questions to students, and students listen and react to questions; (3) then the teacher provides individual class work or group work and students work on the tasks; (4) the teacher then corrects selected exercise books and gives corrections to the tasks if time allows; (5) and finally the classroom is closed with group or individual home works. These are procedures and practices used by a mathematics teacher of the traditional teacher-centered type of classroom instruction as discussed in chapter two. This trend of classroom practice is called seatwork (Serrano, 2012).

If the mathematics classroom practice is required to be connected to real life situation, the activities and tasks to be accomplished should resemble to students' real world. This is related to instructional methods and changing perception of mathematics teachers into the view that it is possible to organize mathematical tasks in a way that look like out of school mathematical practices. All teacher and student participants believe that mathematics is applicable in real life work related activities. However, teaching materials and teachers do not present mathematical concepts and procedures in relation to such real world simulations in order to connect it with students' out-of-school experience. It is this poor activity structure of the classroom mathematics presentation and tasks that led students to view mathematics as a subject with double faces that differ in note memorization and examination. Teachers also believe that student centered and participatory types of instructional methods are important to connect mathematics to students' cultural activities. However, when observed in the actual classroom, they didn't try to organize classroom activities to resemble out-of-school workplace activities that involve mathematics.

This shows that the mathematics classroom activity structure is not similar to that of out-of-school goal directed structure of workplace activities. It is possible to cross examine this difference from the data given in sections 4.2 and 4.3 of chapter four. Where as the mathematical ides in the workplaces such as house building came into being or practice from the problem of the goal-directed activity, the mathematical concepts or topics in the classroom come to students from the teacher (see the case of Mr. Kakhisho for instance). In the case of the house builder, the double stretch of the meter and measure the length of one side, reading the different labels of the instrument, and then adding the two numbers is a consequence of the real problem of mismatch between the measuring instrument and the length of the side intended. In the classroom, the teacher explained about decimals and gave problems to students. The goal of the student in solving such problems is to satisfy his/her teacher.

Moreover, the motive of the activity is also another observed difference. The motive of performing money counting and mental computation or arithmetic in pottery making or in traditional beer selling, for example, is to earn money. But the motive of students for tackling addition problems in the case of the grade four students' classroom of school B, for instance, was to get the correct answer to the problem and fulfill classroom requirements. Furthermore, the motive of the shopkeeper in putting sugar on the balance and measuring the amount of one kilo of sugar is to sell and get money without loss where as the motive of the grade five classroom of school A for drawing the balance on the blackboard is to compare numbers for nothing. This shows that it is important for mathematics teachers to introduce new mathematical concepts to students in a way or situations that engage learners in real life problem solving.

Although not observed practically in the classroom but told by a teacher in the interview session, the following is an example of such tasks. “If your father brought eight caramels and wanted to divide to four of his children equally, how many caramels will each child get?” (Ameha, 5/11/2013). This is a real life problem usually solved by parents. Such tasks need to be used in every mathematics classroom that intends to connect the two situations. Such problems and tasks, if really and appropriately used in classrooms, are helpful in making the classroom mathematics connected to real life.

Therefore, classroom mathematics shouldn’t resemble to out-of-school practices only in methodological and activity structures but also the activities should revolve around tasks that resemble to real-life situations. This means, organizing tutorial and remedial classes for the purpose of reviewing and repeating topics for low achiever students is not enough for mathematics to be understood well. Instead each mathematical concept taught in the formal classroom activities should have an activity structure that resembles out-of-school and workplace activity structures. This involves preparing and using tasks that simulate the reality outside school, procedures and solution strategies that are used in real life workplaces, and real and achievable objectives. Another difference between the two situations is that the workplace mathematics performers can explain why that particular mathematics occurred in work and why they did in that way in terms of their motive and the artifacts involved, but students explain in terms of fulfilling course requirements and the procedures learnt in class.

The above arguments from the data of this study, of course, agree with the literature documented from research (see for example, Barta, 1995; Masingila, 1993). But, how can teachers use the mathematics practiced in workplaces and games with respect to a particular academic mathematical concept? It is possible to provide suggestions as answers to this question from the data in chapter four and the literature (e.g. Chikodzi and Nyota, 2010). For example, the game ‘geveta’ can be used to teach counting and sharing because the players count the number of holes and grains in each hole, they divide the holes called houses equally and this shows sharing and division. It can be also used to teach sets, empty sets, elements of sets, multiples and divisors of 12. This game can be also used to teach probability related concepts. Herding cattle can also be used to teach fractions where an employed herder computes his/her share according to the agreement made at the end of the employment year and expresses his/her share in terms of fractions such as half, one-third, or one-fourth of the young population of the cattle bred during the course of employment. More can be taken from the data in chapter four.

The data in section 4.3 also showed that the organization and management of mathematics classrooms in a similar manner as in the real world workplaces depends on the attitudes and perceptions of the teaching materials and teachers themselves. This is because those teachers (e.g. Mr. Zelalaem of grade five teacher in school B) who believe there is no different mathematics in the real world practices than the textbook and classroom mathematical concepts and procedures would not be motivated to organize such connected/simulated classrooms. Not only this but also some teachers believe that it is the textbooks writers or the school principals who should encourage this practice by presenting cultural ideas of mathematics in the textbooks and by allocating budget for teacher to do such contextualization activity. That is why most teachers were not observed contextualizing mathematics concepts in the classroom except Mrs Neyni and Mr Kakhisho of school B. Sawyer (2008) also reached to similar conclusion as presented here.

Other factors (as discussed in chapter four) that affect the practice of connecting mathematical concepts to students' out-of-school experiences in the classroom include the teaching experience of the teacher and the teacher's familiarity with students' culture and community activities. Moreover, professional development related seminars and workshops that the teacher participates and the motivation of school management to encourage teachers to study the local community and use findings in their classrooms are variables that influence the connecting practice of the teacher.

As discussed in chapter four, the mathematical emergent activities and goals in workplaces arise from and are solved through interaction with peers and customers. Classroom tasks should proceed in a similar manner. So, teachers should encourage interaction between students in the classroom so that poor learners can get assistance from their able friends. Interaction among peers is also helpful to students in that they can ask each other and show or demonstrate their experiences and potentials without feeling shy. Guidance of the teacher provided while students are engaged in tasks and activities can create another social interaction that will enhance the emergence and solving of misconceptions and misunderstandings. The student-centered teaching methods, the one-to-five grouping systems, and other student participatory classroom activities mentioned by participants are sources of social interactions in school mathematics classroom. But, how should an effective interaction look like in the mathematics classroom? It is important to observe and examine how the interaction in workplaces leads the two parties to effective mathematics learning and problem solving.

Simply forming groups of three or more students and giving a mathematical problem to be solved can not be effective initiator of interaction and learning. This means, the mathematics activities and tasks should encourage interactions or collaborations among students. This can be achieved through simulating real life phenomena and practices in the classroom. For example, in teaching addition of decimals, rather than giving and asking the groups of students to solve decimal addition problems such as '0.3+0.75', it is possible to make students to produce their own decimal numbers and add them. This may require the teacher to prepare an object (e.g. a rectangular sheet) whose dimensions have unknown lengths and need to be measured and he/she can give a meter stick with centimeter labels in it. The task for students now may be adding the lengths of two dimensions, finding perimeter of the object, and so on. When students try to measure the dimensions and perimeter of the object, they may face a problem similar to that of the coworker's difficulty in the house building workplace given in chapter four. To solve this emergent problem, they may interact with each other to find ways out. Previous studies also support that the teacher's effort is crucial in designing and implementing mathematical tasks that encourage interaction. For example, it is believed that "the contexts of activities need to start with the learner and need to encourage interaction with their construction of meaning" (Boaler, 1993; 344). Further, Boaler (1993) suggested that classroom interaction is important for students to develop beliefs on mathematics and meanings of mathematical concepts in relation to their out-of-school activities. Bishop (2008) argued that classroom interactions facilitate the development of openness value of the sociological component of culture. This openness value develops when students practice to justify and defend their solutions and answers publicly in the mathematics classroom. Such activity was observed in Mr. Kakhisho's mathematics classroom of school B. In this classroom, students were given tasks on decimal multiplication to solve in groups of students on the same desk. After some minutes, the teacher asked for group representatives to present on the blackboard, and then each presenter was encouraged to stop in front of the classroom and defend to questions raised by the teacher and peers.

Cultural conventions and artifacts can also be used as teaching and learning aids in the mathematics classroom. Artifacts such as abacus are helpful for achieving counting and number sense related classroom objectives. Concrete objects such as circular paper and pictures of traditional circular bread are used as artifacts to help teaching and learning of fractions in the grade five and six classrooms observed. Currency system and money notes can be used as classroom artifacts as they are used in everyday and workplace activities as techniques and means of mathematical computations. However, especial attention should be given when choosing local artifacts and ideas related to mathematics. The case of factories and industries mentioned in the textbooks as discussed in 4.3 of chapter four can never be facilitators for connection. It is because, at the present time, the students in Wag Khimra are not exposed to such things.

Background of the students is also another issue that needs addressing when thinking connection between classroom and outside school settings. The findings of Wager's (2012) study of how teachers incorporate children's cultural and out-of-school mathematics in classroom instruction on three students' out-of-school experiences. These are: using these experiences of learners as contexts to present problems; linking these experiences to school mathematics; and identifying embedded mathematical practices prominent in these experiences. According to the teacher participants of this study, students use their out-of-school mathematical experiences to simplify and solve classroom mathematical problems. This is similar to Wager's (2012) first finding. As discussed in chapter four, however, some teachers view these real life experiences of students as full of misconceptions and limitations. The use of repeated addition instead of multiplication is seen as one of the limitations of indigenous mathematical knowledge. Understanding the limitation of a traditional practice is an important step forward in trying to mathematize school mathematics to the real life situations. But this should begin from the students' prior understanding and it is the students' themselves who should see the difference and appreciate school mathematics.

To sum up this section, it is important for a primary school mathematics curriculum, textbook and teacher to be familiar with the students' cultural background in order to make mathematical concepts meaningful to the learners. This is fulfilled by the curriculum and teaching materials to some extent at least by making the language of instruction the local language, Khimtigna. This is because one of the reasons of making medium of instruction in lower grades with their mother tongue is for students to understand the material very well and thereby build strong background. Establishing a strong connection between students' out-of-school practices and the classroom mathematics culture begins from the use of students' local language and ideas. Therefore, it should be an asset for teachers to draw on and build meaningful mathematics. However, what has been observed in classrooms is otherwise.

5.3. Conclusions

The intention of this study was to contribute to the effort of teachers in making their instruction relevant to and engaging learners. To this end, an important aspect of creating conducive mathematics classrooms and situations, the out-of-school mathematics and its role in improving classroom mathematics instruction, was examined and documented. As discussed in chapter two, more than anything else, teaching is the one and the first that shapes students' current learning and future career. NCTM (2000) claims this as "students' understanding of mathematics, their ability to solve problems, and their confidence in, and disposition toward, mathematics are all shaped by the teaching they encounter in school" (pp. 16-17). This shows that mathematics teachers are responsible for making their classroom mathematics suitable to the learners by incorporating out-of-school mathematical ideas in the classroom instructional practices. Therefore, from the literature's point of view, it is safe to assert that learners in a given classroom have mathematical knowledge and ideas gained from their culture and everyday life and this experience can be used as a contextual basis for classroom mathematical practices. This claim is related to the following finding from workplace and game settings

One finding of this study from the data of workplaces and games examined is that mathematics is more understood and can be friendly to the learners when it is encountered in action. The settings of actions investigated in this study are the workplaces and games where participants engaged in their routine and goal-oriented activities. The intention of each participant in each workplace or game was not to learn mathematics but to accomplish work related goals such as making a pot or wining the game. When the activity is going on, some other goals emerge and previous goals disappear. One of such emerging goals is solving mathematical problem which leads the worker (e.g. potter) to be engaged in mathematical learning when searching of good ideas, solution techniques, short methods, and simpler approaches. In doing so, the worker (e.g. potter) used previous experience, artifacts and objects (e.g. money notes), interacted with others, and used conventional rules. This shows that outside school settings such as workplaces and games have embedded mathematical concepts, techniques, procedures, and thinking that are related to the topics and concepts presented classrooms.

Moreover, the data and findings of this study also showed that there is a direct relationship between activity and mathematics, social interaction and mathematics, artifacts and mathematics, work-related and mathematical goals, as well as motive and mathematics doing. This shows that the activity structure of a particular goal-related work plays an important role in the emergence of various mathematical ideas and concepts. For example, at the first stage, the 'tilf' maker negotiates with her customer on the service fees which leads to arithmetic computations. In the next stage, s/he has to make the tilf and this leads to designing which in turn leads to counting the threads in the cloth and then putting points and drawing lines. This process engaged the knitter in constructing geometrical shapes. This implies that mathematical knowledge is constructed and learnt more effectively when people engage in actions related to real.

This embedded mathematics implies that it is possible to design similar activities in the mathematics classroom so that students can feel at home or at workplace while they are in school. This design requires preparing real life objects, goals, motives, conventions, and other work related aspects in order to simulate the workplace and bring into the classroom. Regarding this issue, from the data collected and analyzed from schools, some teachers were observed considering students' experiences with mathematics outside of school by incorporating context in problems, but still others were reluctant to act in the way suggested above. From this, it can be claimed that teachers belief the importance and want to connect the students' in-and out-of-school mathematical practices but they have challenges such as lack of familiarity to the learners' community and environment, lack of resources, and reluctance of school administration to encourage this practice.

Another finding of the current study is that textbooks state about the relevance of connecting out-of-school experience and classroom mathematics but this has not been seen in the contents and activities they display. So, it is possible to claim that textbook (curriculum) developers missed an opportunity to use a rich out-of-school experience of students to make a seemingly abstract mathematics at schools more meaningful to students. They definitely have talked the talk but failed walking the walk.

5.4. Implications

The educational demands of the current government and generation in Ethiopia are firmly linked to science, mathematics and technology. These should not be simply copied from the curricula and textbooks of developed countries for the mere sake of developing the nation. Instead, science and mathematics education throughout the educational levels should be adapted to suit the socio-cultural contexts of the different nations and nationalities of Ethiopia. To this end, all stakeholders of mathematics education need to work collaboratively to improve the practices at all levels including curriculum level, textbook level, and classroom level to make every concept delivered in school connected to the learners' real life and future career. That is what the major findings given at the end of chapter four imply.

At curriculum level, the experts producing the mathematics curriculum should be aware of their ultimate target population. This awareness creating includes examining the socio-cultural and historical context of the people, updating them selves with the current economic, social and cultural context of the target people and consulting elders of the target people about the curriculum they are producing. Similarly, textbook writers should go deep further because the concepts presented in the books should be related to the students' real world in terms of the tasks and activities, the examples, problems and their solutions, ideas carried, and so on. There is gap in all the analyzed teaching materials with regard to these issues. Moreover, still the observed classroom practices of teachers were not aware of these issues. To fill these gaps, the traditional and indigenous knowledge forms and practices of everyday activities need to be thoroughly investigated, documented, and made available to textbook writers and teachers. To this end, as has been tried to shed light on Wag Khimra's community, it is worth studying other communities as well. Moreover, the challenges that teachers face with regard to this issue can be partly solved during the teacher training period. Therefore, teacher training colleges need to work hard on this issue because teachers must be made fully aware of this aspect of their career.

With regard to further research, the current study examined and documented that people with no educational background and modernity use mathematics in workplaces as a tool to perform their work related activities successfully. This can be extended to investigate further questions such as: how is mathematics practiced in other workplaces that are not included in this study? How is mathematics used in other situations such as home? Where did this mathematics come from? How did they learn it? Moreover, researchers can extend the issue of identifying out-of-school mathematical ideas, concepts, techniques and practices to other ethnicities of Ethiopia. This requires establishing the 'Ethnomathematics Project in Ethiopia', which is already underway in other African countries such as Mozambique and South Africa.

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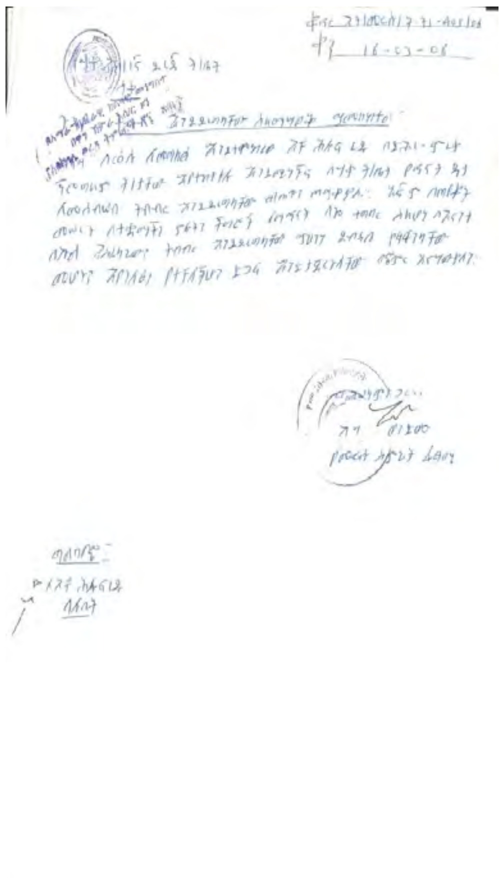
Appendices

Appendix A: Entry Letters from the Two Wereda Offices



Appendix B. Research Participant Informed Consent Form

i. English Version

Dear Participant,

You are invited to participate in a research study entitled "Everyday Mathematics in Ethiopia: The Case of the khimra People" To better understand from your viewpoints about how you use indigenous mathematics in your everyday practices. The study is being conducted by me, Mr. Hilluf Reddu, Addis Ababa University, Department of Science and Mathematics Education.

What things will be involved if you participate in this study? If you decide to participate in this research study, I will ask that you allow me, the researcher, to collect data related to the everyday mathematical practices that take place in your activities. I plan to make 2/3 visits to your workplace and classroom/school for 30-60 minutes in order to perform the following:

1. Conduct one-on-one 30-50 minutes audio-taped interviews with you.
2. Make observations while you are working in your routine everyday activities and audio/video record the practices.
3. Have copies and pictures of some of your documents.
4. Following these visits, I, will record field notes in a journal. .

Are there any risks or discomforts? The risk associated with participating in this study is loss of confidentiality through your interview responses. To minimize this risk, I will use pseudonyms when transcribing and analyzing your responses.

Your privacy will be protected. Any information obtained in connection with this study will remain confidential. Information obtained through your participation will be used to fulfill an educational requirement (i.e. dissertation), to publish in a professional journal, or to present at a professional meeting using pseudonyms for your name.

If you change your mind about participating, you can withdraw at any time during the study. Your participation is completely voluntary. If you choose to withdraw, your identifiable data will be destroyed immediately. Your decision about whether or not to participate or to stop participating will not jeopardize your future relations with Addis Ababa University, the Department of Science and Mathematics Education, or your relations with schools.

If you have any questions about this study, please ask them now.

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO PARTICIPATE.

____________________________ _____ ____________________________ ____

Participant's signature Date Signature of Investigator obtaining consent Date

____________________________ ____

Printed Name Printed Name

ii. Khimtigna Version

ኪብርድርነቅ እን ጥናቲል ሲትፍሽርነቅድ፡-

“ኽምጢዙ አቀ-ህብሪል ግርየጨሽቅ ቱ ሩሄል ፅቦ እግዘኻስሽዙ ኣርቅት” የው ድህረ-ምረቀዙ እቻዘነ ጥናቲል ሲትፍሽትነኘ ክብርዝ ዋቅረኩን፡፡ ኣጥናዘቴዙ ሽኙድ ሕሉፍ ረዱ የኻ፡፡ኣዲስ ኣባባ ዩኒቨርሲቲ ፍጥረትዙ ሳይንስዝመ እግዘ-ኻስሽዝቱ ክንድኻ ክፍሊል ድህረ-ምረቀ ክንደተ የኻ፡፡እን ጥናቲል ሲትፍሽርን ክተቓለድ ነይርንሽ ክተግርየጨሽቅዙ ሰቪል እግዘ-ኻስሽድ ኣውሽርን ጣቅምሽርነኘ ኣጥናዞድ ኣርቅጠኘ በጣምዝ ክሽስጠ ቸለኩ፡፡

ኣኒን ጥናቲል ሲትፍሽትነ ዊስንድርንሽ ክተሰቪል ጣቅምሽርኖ እግዘ-ኻስቪል ክታይስ ሚዝር ኣክሽጨ ፊቅድትነኘ የኻ ጣይቆድ፡፡እን ሊኘ ኣርፊል ክሰቪል ተጣኻ 30-60 ደቒቓ ክጅቅ ውይይት ፃሽጨም ክሰሽደ ቓልጨም የኻ በኖድ፡፡ ተጣንድም ቲክነቁ ቲግሽረንድ ሰራጨ ቸለኩን፡-

1. ክጅቅ 30-50 ደቒቓ ቃለመጠይቅ ፃሽኩን፡፡ እኒን ቃለመጠይቅድም ቴፕ ሪከርደሪዝ ቐዳቐኩን፡፡
2. ክሰሽድ ሰራሽራኻ ፃሽሮድቅ/ሰራሽሮድቅ ቓላኻ ይቴፕ/ቪድዮ ሪከርደሪዝ ቐዳቐኩን፡፡
3. ክዶክሜንተንድ ቅጂ ፃሽ ዊንም ኻተፎቶድ ፊስጨ ቸለኩን፡፡
4. ይደፍተሪል ክጅቅ ዋርጣኻ ችኻቁ ሚዝርጣንድ ማስታወሻ ፃቀኩን፡፡

ክማንነትድ ላዘ ኣጅር ኣርቐሽንቅ ክሹኻድ ላውጥ የኻ ኔሮ ሚዝርድ ጣቅምጮድ፡፡ ክመንትድም ሚስጥሪዝ ፃይሽቶ የኻ፡፡ ክጊስ ችኻሾ ሚዝርድ ይክንድኺዝ እቻዘነንስ፣ ጆረናሊል ፃፈነንስ፡ሞየዙቁ ኣኸሽጢል ኣልሰነንስ ጣቅምጨንድ ክሹኻድ ላውጥ የኻ ጣቅምጮድ፡፡

እኒን ጥናቲል ሲትፍሽኖድ በኒርሽ ዊንም ሲትፍሽራኻ ማኽሊል ፍተ/ኣቋርፅተ በንርሽ ኣውማኞ ጊዜል ፍተ ቸልደኩ፡፡ እን ጥናቲል ሲትፍሽሮድ ክበኔዝ ኣጠ ጥውሽኩ/ተሚሰኩ፡፡ ሲትፍሽኖድ በትርሽ/ኣቋርፅርሽ ክነይረቁ ሚዝርጥድ በውዝ የኻ ድሶድ፡፡ ሲትፍሽተ ዊንም ሲትፍሽቀር ይተ ዊንም ሲትፍሽራኻ ዊንድር ኣቋርፅተ ዊስንራንድ ኣውማኞ ተቋሚጅቅ (ኣዲስ ኣበባ ዩኒቨርሲቲ፣መንግስቱ ዊንም መንግስቱ ኣዮ ድርጅተንጅቅ)ፃይሮ ዝምድነድ ዊንም ዲምቅሽንድ ጨቅሻውም፡፡

ክሲትፍሽኖድ ኣቈ ላዘ እን ጥናቲል ሚልክትሾ ዋቅርጥ ፃይርኩርሽ ነን ጣይቅተ ቸልደኩ፡፡

ንዬይል ነይሽተቁ ኻስሽድ ኣንብር ዊንም ኣንሽኻንድ ወሽር በትር እን ጥናቲል ሲትፍሽጨ ዊንም ሲትፍሽቀር ይር ዊስንተ ጥውሽኩ/በንሰኩ፡፡ ክፊርመድ እንሳይል አቈርድሽ/ፊርምርሽ እን ጥናቲል ሲትፍሽተ በንረኘ የኻ ቓሊሶድ፡፡

ሲትፍሾ አጅሪዙ ሹኻድ	ፊርመ	ግርየድ	ክሰሽድ
ኣጥናዞይዙ ሹኻድ	ፊርመ	ግርየድ	

Appendix C: Interview Protocol in Workplace/Gme Setting

i. English Version

Introduction

The aim of this interview questionnaire is to collect the necessary and relevant information for the Ph.D. paper writing entitled **"Everyday Mathematics in Ethiopia: The Case of the khimra People"** Therefore, to achieve this aim, the researcher needs your cooperation to express your feelings and understanding in reflecting on the questions. The researcher is interested in your everyday mathematical practices in your workplace/game. Please understand that there are no rights or wrong answers to these questions. I am only interested in your opinions and ideas. Your responses will be audio taped.

A. Formal Interview Quetions

1. Gender: _____________ Age: ______ Mother language __________
2. Number of years working in this workplace:_______________
3. Have you ever attended school? If yes, at what grade did you stop going to school?
4. Where are you from? Were you born and are you living in the village?
5. What is your job and how many years did you work in this job? How did you learn this job? How do you begin and proceed your job?
6. What goals do you have when you enter to your job every morning? How do you do your job every day? How do you begin and proceed? What raw materials, knowledge and skills do you need to produce these materials? What materials do you produce?
7. What is your total expense? How much money do you earn when you complete one cycle of this job? What is your profit? How do you calculate your profit?
8. How do you negotiate with people when you buy and sell goods? How do you fix the prices to sell?
9. What is the game you are playing called? Is that common in this area?
10. What are the structure, procedures and rules of this game?
11. What skills are required to win this game
12. What mathematics do you use in your work? Do you know the money notes?
13. Do you use school learned math in your work related activities?
14. How do you know and tell time?
15. How do you know/show directions? Say for example, a guest wanted to come to your home and called in your phone and asked "where is your house?" by specifying that he is around the square (piassa). How could you tell your house's location? Do you know about west, north, east and south directions?

B. Mathematial Tasks

1. Ok! If a kil is sold for 9 birr, jevena for 18, dish for 21, pot for 37, migune for 50, and gen for 79 birr, what total birr will you have?
2. What will be the result when we add 27 and 38?
3. You harvested 13 quintal wheat from one of your farmlands, 38 quintal sorghum from the other,19 quintal corn from the third farmland.How many quintals did you harvest totally?
4. If you had 8 cows and get other 3 cows from saftynet, how many cows will you have totally?
5. If you produced one Netela and sell it by 55, one Kuta by 100, and one Gabi which will be sold by 190 birr, how much money would you have totally?

6. You have 34 ETB and you bought a killo salt for 5 ETB, 5 eggs for 13 ETB, then how much money will you remain with finally?
7. If you had 200 birr and you bought a cloth for 65 birr, what will be the remaining money? What do you call the method you used to get this answer?
8. What will remain if you take 56 from 98? What if we take 59 from 98?
9. When you buy clothes by the one-third of this 420 birr, what is remaining?
10. If you sell 5 dishes 15 birr each, how much money will you have totally?
11. If we claim that a quintal 'teff' costs 1553 ETB, what would 6 quintals of 'teff' cost?
12. Ok! If you pay 53 birr for one Kiwi, how much will you pay for 8 kiwis?
13. What number represents half a meter? How many meters does 300 centimeters represent on the instrument? What will 2500 grams be in kilograms?
14. What is the half of 214 birr? What about if we divide this 214 birr to three persons equally?
15. Ok! Let's say you baught a derzon pens by 54 birr. What will 18 pens cost together? Ok! What about 20 pens together?
16. By selling your products, you have accumulated 2400 birr. If you divide this to your 4 children equally, what will be each child's share?
17. If you divide 689 to 13, what is the quotient?

ii. Khimtigna Version

ሰብ ስፍሬዙ ቃልዙ ዋቕረ ፕሮቶኮል-ጉዝን

ሀ. ጥወነ

"ኽምጢዙ አቀ-ህብሪል ግርየጨሽቅ ቱ ሩሄል ፅቦ እግዘኻስብዙ ኣርቕት" ይሽቶ ኣውሪል ኣጥናዞድ የን ሻ ፒ ኤች ዲ ድግሪዝ እቻዘኖ ፅሁፊል ጣቅመቁ ሚዝርጣን ኣክሽነንስ የሻ-እኒን ጣይቀነይዙ ዓለመድ። እኒን ጥናቲል ሲተፍሽረንስቅ ሚዝየንዛሻ እግዘ-ኻስብ ጅቅ ፃየፃይሽቶ ክሰቢል ጋጥመው ታሪክ ዊንም ዲዝሻትድ ይግስ ግሽሪስተ ጣይቀኩን። ክኻስብድ ዋቕሬል ኣትኩርድር ነይርሽ ቀሶ ኣቐኩ። ይሰብድ ዲቁዲቁ ጣይቀኖዝመ ወሽኖዝ ኣቐንስቅ ንቕያ ጊዜድ ክት የሻ ዊግትሮድ። ክድመድ የት ቴፕድ የን ቐዳጠ ማጥን ቓፅ ይር ዊግትርሽ ቀሶ ኣቐኩ።

እን ጥናቲል ሲትፍሽር ሚዝር ነይተ ቲስመምሽረንስቅ ሚዝየንዘኩን!!!

ለ. ዋቕረንጥ

1. ክምቾ ብዝሮ ቆንቆድ________ ዕድሜድ፡ _________ ፆታ፡ _________
2. እነኹርሽር አን መ ሊግዝሮዳ? እንመ ዊትርቅ ፅብሮዳ?
3. ክንድሻ ሻኒል ጥውር ክንድር ኣርቕረርመ? ዋቐ ክፍሊል በትሩ? ውራር በትሩ?
4. **ክሰብድ ወረኘ የሻ? ክሰብድ ኣውሽርክንድሩ እንሰቢል ዋቐ ኣምት ሰራሽሩ?**ክሰቢስ አቅኘዝ ቀንዶይዝመ ሽቅትሮ ክፍልድ ኣውዲን የሻ?
5. **ክሰብድ ቀሶዝ ኣክንወነንስ ውር ውር ጥሬ-ዕቃ ዊንም ኅዝ የሻ ተሚሶድ? ክሰቢስ ውር ውር ኅዝ ዊንም ምርት የሻ ኣምርትሮድ?**
6. **ክሰብድ ኣወሽር የሻ ኪርምሮድም ፃሻዝሮድም? ክሰቢል ቅሽሻ ጥውራንድ ውር ውር ኣቅድር የሻ ጥውሮድ? ክሰቢል ውር ውር ቾልት/ኣርቕት የሻ ተሚሶድ?**
7. **ክሰቢል ክደምበኻጢጅቅ ኣወይር የሻ ኻሳብ ላወላውጥሽሮድም ቲስመምሽሮድም?**
8. **ሰራሽረቁ ኅዘንድ ቂረንድ ዊንም ክደምበኻጥድ ኪፍልስረንድ ክወጪድ፤ትርፍድ ኣወሽር የሻ ኻስብሮድ?**
9. **ክቾዝኺዙ ፍራትድ ዋቐ የሻ?**ወረኘዝ የሻ ሊኪሮድ? **እንቑጠ ፍራት ፃዮ ቾዝኺል ዋቐ ሽንበር ዚረ ፊዝተ ቾልደኩ?** ኣውሽር ኣርቕሩ?እንቑጠ ፊዝር ውርቑጠ ግብር ኻብዝትር?
10. **እን ዋርደድ ውር ይሽተኩ? እን ጅውኔል ዲዝሻሾ መ?**
11. **እን ዋረዴል ውር ውር ኸገን፣ፃኘ፣ቾልት ተሚሰኩ?**
12. **እግዝጥድ ኣውሽር አግዝራ?** ኣዊስ ክንድሩ? **እግዘ ኻስቢል ክቓለድ ውር የሻ?** እግዝጢዝመ ሻተሰላዘነቀኣዝ ኣዊስ ተረኽ ይር ኣምንዳ?
13. **ክሰብ ሰራሽኖይል እግዘ-ኻስብ ጣቅመሽረኩ መ?** ኣውሽር የሻ ጣቅምሽሮድ?
14. **እስቲ ጊዝድ ኣወሽርን ሚግዝርነኘ ድቁ?ግርቅድ ኣወሽር የሻ ሚግዝሮድ?** ሰዓትድሰ ኣውሽርን የሻ ኣርቕርኖድ? ነን ዋቐ ሰዓት የሻ? ኣቅጠጨድ ሳ?
15. ቁርሽንድ ኣርቕረኩ መ? ኣወሽር የሻ ቾዝሮድ?

ሐ. እግዘ-ኻስብዙ ሰበን

1. **እሺ! ቂልድ 9 ቁርሽንዝ፣ ጀሽነድ 18፣ ድስትድ 20፣ጭንድ 37፣ ሚጉነድ 50፤ገንድ ቆሽ 80 ቁርሽንዝ ቂርሽ ጥቅለዘ ዋቐ ቁርሽን ፃይር ጡትር?**
2. **ቅምስ ጣልፍተ በንር ሰሮ ኺድያትድ 30 ቁርሽንዝ፣ የወንጠጅድ 26 ቁርሽንዝ፣ ኻፀ ተኮድ (ቅጠሊየድ) ቆሽ 33 ቅርሽንዝ ጅብሩ ይንሽ ጥቅለዝ ዋቐ ቁርሽን ፊስሩ የነት የሻ?**
3. **ክላው ቾዝኺስ 13 ኩንታልዝመ ግሽርዝ ዚሩ ቾሻሩ፤ክላዘ ቾዝኺስ ቆሽ 38 ኩንታለን ሜለ ቾሻሩ፤ ክመስኖይዙ ቾዝኺስ ቆሽ 19 ኩንታለንዝመ ሲዝነዝ ባህረምል ቾሻሩ፡፡ ጥቅለዝ ዋቐ ኩንታለን ድልምዙን ይተ ቾልደኩ?**
4. **ክፃይረቁ 8 ቅሚል 3 ቅም ቾሻረሽ ዋቐ ቅም ኣንጠኘ፣**
5. 1200ይስ ኣኮ ላ ቁርሽኒዝ ጥር ጅብርሽ ዋቐ ፃይር እዳትር?
6. **ክፃይረቁ 34 ቁርሽኒስ ጒይር 5 ቁርሽንዝ ጮጥር ጅብሩ፣ 13 ቁርሽንዝ ቕሉን ጅብሩ፡፡ ዋቐ ቁርሽን ፃይር እዳሩ?**
7. **200 ቁርሽን ፃይር ዊንድር 60ዝ ፃርቀ ጅብርሽ ዋቐ ቁርሽን ፃይር እዳትር?**
8. **98ቲስ 56 ጒንሽ ዋቐ እዳጡ?** 98 ቲስ 56 ቂንስርሽሳ?
9. **420 ቁርሽኒስ ሽውነድ ጉይር ፃርቅጥ ጅብርሽ ዋቐ ቁርሽን ፃይር እዳትር?**
10. **ኣኮ ድስተንድ 15፣15 ቁርሽንዝ ቂርሽ ጥቅለዝ ዋቐ ቁርሽን ለምርትር?**
11. **ላው ኩንታል ጣሽ 1553 ቁርሽን ፊሰኩ ይንሽ ዋልጠ ኩንታል ጣብድ ዋቐ ቁርሽን ኣንጥቁ**

12. ላው ኪዊ ቀለም ጅቨራንድ 53 ቁርሻን ይውረኩ፣ ሰውጠ ኪዊ ቀለመን ጅቨራንድ ዋቐ ቁርሸን ኪፍልትር
13. ሲዘላ ሲዘላ ፊሰቁ 6 ፃርቅጥ ሰራሽር ኻትር ኣርዬል ፊሰር ቂርሽ ጥቅለዝ ዋቐ ቁርሸን ፃይር ጡትር?
14. 50 ሳ.ሜትርድ ዋቐ ሜትር የነት የሻ? 80ሣ.ሜትርድሳ? 2500 ግራም ሰኳርድ ዋቐ ኪሎ ኣንጥቁ?
15. ላው ደርዘን እስክርቢቶይዙ ወየድ 54 ቁርሸን ኣቐሸ ክት 18 እስክርቢቶወንድ ዋቐ ቁርሸንዝ ጅቨትር?20 እስክርቢቶወንድሳ ዋቐዝ ጅቨትር?
16. 214 ቁርሸኒዙ ግቨርድ ዋቐ የሻ ተሮድ? እናይ 214 ቁርሸንድ ሻቔ አቅዝ አድልንሸ ሰ ዋቐ ዋቐ ቾሻጡ? እሺ! 214 ቱ ሸውነድ ዋቐ የሻ?
17. 689 አድልሻንድ 13ሰ ዋቐ ዋቐ ቾሻጡ?

ሚዝየንዘኩን!!!

Appendix D: Teacher Interview Protocol

i. English Version

Introduction

The aim of this interview session is to collect the necessary and relevant information for the Ph.D. paper writing entitled **"Everyday Mathematics in Ethiopia: The Case of the khimra People"** To achieve this aim, the researcher needs your cooperation to express your feelings and understanding in reflecting on the questions. I am interested in your everyday mathematical practices inside or outside school in relation to the community in which you and your students live, mathematics curriculum and classroom instruction. Please understand that there are no rights or wrong answers to these questions. I am only interested in your opinions and ideas.

Questions for Formal Interview

1. Gender: __________ Age: ________ Mother tongue language: ___________________
2. Where are you from? Were you born here or settlement? How did you come to teach in this village? Do you live here??
3. Last year of education ________________________
4. Have you taken a teaching methodology course of training? What type and when?
5. What do research, policy, curriculum, and the courses you took say about math teaching?
6. What successful and/or unsuccessful methods of math teaching can you mention?
7. What is your view on math teaching?
8. What techniques do you use to achieve this approach of teaching view? How? Why?
9. What successful and/or unsuccessful math teaching methods do you know? How did you know this method is successful? Is abacus cultural?
10. How do you create confortable classroom for your students?
11. Do you encourage students to bring and apply their out of school experience in the math classroom? Do you make your students bring objects or ideas related to math? How?
12. Do you think students will perform well if they work in groups in the classroom? As I observed in your classroom, you didn't use gruopwork method. Why? Why didn't you connect the concept with learners' culture?
13. Do your students use their society's methods of math calculations in class?
14. What do you think is the relationship between math and culture? What is the similarity and difference b/n out-of-school mathematical practices and in-school math?
15. What role can they play in the math classroom if you use concrete materials while teaching?
16. Have you ever observed the people around your school and home using mathematical methods and ideas in their everyday work related activities?
17. When you plan to teach math or when you teach math in the classroom, do you consider the students'background and culture? How and why?
18. What obstacles can you mention that hinder the incorporation of learners' out-of-school cultural ideas in the math classroom?

ii. Khimtigna Version

ክንሰጢዙ ዋቕረነ

ጥወነ፡- "ኽምጢዙ ሩሄል ዊንም ግርየጨሸቅቱ ሰቪል ፅቦ እግዘ-ኻስብዙ ኣርቕት" ይሽቶ ኣውሪል ኣጥናዞድ የን ሻ ፒ ኤች ዲ ድግሪዝ እቻዘኖ ፅሁፊል ጣቅመቁ ሚዝርጣን ኣክቨነንስ የሻ-እኒን ጣይቀነይዙ ዓለመድ። እኒን ጥናቲል ሲተፍሽረንስቅ ሚዝየንዛሻ እግዘ-ኻስብ ጅቅ ፃየፃይሽቶ ክሰቪል ጋጥመው ታሪክ ዊንም ዲዝሻትድ ይግስ ጊቨሪስተ ጣይቀኩን። ክኻስቨድ ዋቕሬል ኣትኩርድር ነይርሽ ቀሶ ኣቐኩ። ይሰብድ ዲቁዲቁ ጣይቀኖዝመ ወሸኖዝ ኣቐንስቅ ንቕፆ ጊዜድ ክት የሻ ዊግትሮድ።

ቃለ-ምልልሲል ጣቅምሽነቁ ዋቕረንጥ

1. ፆታ: ______ ዕድሜ: _____ ምጀ ብዝረው ቄንቄድ __________ ክንድሻድ ኣውን በትሩ/ጊውርሽሩ?----------------
2. ዊትርቅ እን ጣብዪል መ ፅብሮዳ? እን ኻግሪል መ አኹርሽሮድ ዊነስ ላዘ ኻግሪስ ፊልስር ተትረር የሻ? ኣው ኻግሪስ የሻ ተትሮድ?
3. እን ክንድሻ ሻኒል ዋቐ ኣምት ክንስሩ?_________________
4. ክክንድሻድ ኣውን ኻትሩ? ክንሰነ ክንደነ ቲምልክትሽቁ ኮርሰን ዊንም ስልጠንጥ ፊስር ኣርቕረር መ? ኣውን? ውር ውር ዊንም ኣውየቁ?
5. ሪሰርች ጥናትድ፣ ክንድሻ ፖሊሲድ፣ እግዘ-ኻስብዙ ካሪኩለምድ ዊንም ክንሰነ/ክንደነ መፅሃፍድ ክንሰነ-ክንደነ ፃሻይል ውር ይኝ?
6. እግዘ-ኻስብድ ኣውሽር የሻ ክንስሮድ?ውር ውር ቀሰቁ (ውጤታማ ኣቐቁ) እግዘ-ኻስብ ክንሰነ መልጥ ዊንም ዲዝሻት ኣርቕረር? ቀሰቁ ዊንም ውጤታማ ኣየቁ ሳ?
7. እግዘ-ኻስብ ክንሰኖይል ክቓለድ ውር የሻ? ክንስሮ እግዘ-ኻስብድ የት ክክንደጥድ ልብ ይንጠኘ ኣውሽር የሻ ከብስሮድ?
8. እግዘ-ኻስብዙ ክንድኺል ክንደጥድ ላውብጠ ሰራሽሻሽ ውጤተማ ኣንጠ ቸልኘኩ ይር ኻስብረኩመ?ውራ?
9. እግዘ-ኻስብ ክንስተ ኣቅድራንድም ኣቒ ክንስራንድ ክንደጢዙ ቦውረ ታሪክደ ዊንም ሻታግርየጨቨዙ ሩሄድ ዊንም ባህልድ የት ጣቅምሽረኩ መ? ዬ ይርሽ ኣውሽር? ኣዮ ይርሽ ውራ?
10. ክክንደጥድ ክንድሻ ሻኒስ ቢዜል ሻተግርየጨቨቅዙ ሩሄስ ውርውር የሻ እግዘ-ኻስብዙ ክንድሻ ክፍሊል ፃይሻ ተርኘውድ? ክት ነሱ ይር ድቁራሻመ/ኣዝራሻመ ዊንስ ሻታቕም? ውራ?
11. ክክንደጥድ ክክፍል ኣቚል ክንድኘው እግዘ-ኻስቪስ ክንድሻ ሻኒስ ቢዜል ዊንም ሻታግርየጨቨቅዙ ፍልውልዌል ጣቅምሽኗንድ ኣስክስር ኣርቕረርመ? ውር ውር እግዘ-ኻስብ? ኣውዮ ሰቪል? ጣቅምሽኗንድ ቓልድሽ ክግስ ውር ሰሜት ነያ?
12. እግዘኻስብ ክንስራንድ ክክፍሊል ክንሰነ-ክንደነ ፃሻድ የት ምቾ ፃቨነንስ ክንደጢዙ ባኽልድ ዊንም ዲዝሻትድ ጣቅምሻይረኘ ፅጋ ኣቐቁ ገበን አኩሻመ? ውር ውር ኟይ?
13. ክእግዘ-ኻሰብ ከንሰነዊል ባኽሊዙ ጥቕዘድ ወረኘ የሻ ይር ኻስብረኩ? ኣውዮዝ? ላዘ ሰ ክእግዘ-ኻሰብ ከንሰነዊል ጥቕዘ ፃቨው እኩ መ?
14. ላው አቀ-ህብር/ብሄረ-ሰብ ዙ ባኽል ሻቕምቱ ቺት የው እግዘ-ኻስብ ፃይጡ ይር ኻስብረኩ መ? እን ክንስረው እግዘ-ኻስብ ኣዊስ የሻ ተሮድ?
15. ባኽሊዝመ እግዘ-ኻሰቪዝ ዲምቀንድ ወረኘ የሻ ይር ኻስብረኩ? ባኽልድ እግዘ-ኻሰብ ክንሰነዊል/ክንደነዊል ጥቕዘ ፃየው የሻ? ኣወሽ? ባኽሊል ፅቦ እግዘ-ኻስብድ ክንድሻ ሻኒል ፅቦ እግዘ-ኻስቪስ ፊስኑ የሻ? ኣዊ ባኽሊል ጥው?
16. ክክንደሻ ጅልውዜል አቀ-ህብሪዙ ግርየ ጨቨቅ ባኽልዙ ፍልውልወይል እግዘ-ኻስቮዙ ቲግብር ኣስክስር ኣርቕረኩ መ (ተክዘ፡- ክሰብ ስፍሬል፣ ክሻኒል፣ ክዋርደነ ስፍሬል ተከተከቁ)?
17. ግርየጨቨቅዙ እግዘ-ኻስብዙ ቲግብሪዝመ ክንድሻ ሻኒዙ እግዘ-ኻስብ ቲገብሪዝ ውረኘዝ ተከተክኘኩ? ሻተቺተንድስ?
18. እግአ-ኻሰብዙ ክንድኺል ኻትርሽቁ/ኮንክሪት መሰርይጥድ ዊንም ዲዝሻጥድ ኣውዮ ችኘር ዋርድኘኩ? ተክዘ ይውጥን

ሚዝየንዘኩን!!!

Appendix E: Student Interview Protocol

i. English Version

Introduction

The aim of this interview questionnaire is to collect the necessary and relevant information for the Ph.D. paper writing entitled **"Everyday Mathematics in Ethiopia: The Case of the khimra People"** To achieve this aim, the researcher needs your cooperation to express your feelings and understanding in reflecting on the questions. I am interested in your everyday mathematical practices inside or outside school in relation to the community in which you live and classroom instruction. Please understand that there are no rights or wrong answers to these questions. I am only interested in your opinions and ideas. Your responses will be audio taped.

Interview Questions

1. Gender: ________ Age: ___ Mother language :_________________
2. Where are you from? Do you live in the village/town?
3. How did you come to learn in this school?
4. Were you born and grew up here?
5. What is your mother tongue language? How did you come to this school?
6. How is your performance in mathematics? Why do you say that?
7. What are thos things that you like more and don't like more in mathematics? So, do you believe learning math is useful or good for you or not important? Why are you not seeing its importance and hate it?
8. Describe the teaching-learning process in your mathematics classroom. What does the teacher do? What do students do?
9. How does your math teacher teach in the classroom? Do you like this method of teaching?
10. Do your math teachers use ideas and objects from your culture when they teach mathematics?
11. Do your family or the community you live in use mathematics in their everyday activities? What type of mathematics have you ever observed they using? How do they measure length/distance, volume, time?
12. Do you think that the math taught in school and that used in the community are different or similar? Why?
13. Have you ever used the mathematics you learned in school when you are in your out-of-school life activities? Does it help? Can you give me instances or examples when you used school learned math?
14. Can you explain how the school learnt mathematics helps in your out-of-school work?
15. $20-(4\frac{1}{2}+6+7)=$---------
16. $3\frac{1}{2}+5\frac{1}{3}-\frac{4}{7}=$ ____
17. $0.3\text{x}0.25$
18. What do you call the numbers ½,1/3,1/4,1/5,1/8, and 1/10? What does your family and community call these numbers?
19. $\frac{60}{12}\text{x}20=$________
20. If your mother sent you to the shop with 20 birr to buy sugar by 4.5 birr, coffee by 6, and soap by 7 birr. What amount of money will you have to return back to your mother?

21. A farmer produced 3 $\frac{1}{2}$ quintals of Corn, 4 quintals of sorghum, 2 $\frac{1}{6}$ quintals of barely and 1 $\frac{1}{2}$ quintals of wheat from his four farm lands. How many quintals did this farmer produce totally?

22. A house builder wanted to find the area of the base of a rectangular house. If one side is 0.0045 kilometers and the other side measures 0.003 kilmoeters, then what is the area of the house's base?

23. What do we mean by 'showune'? Can you show this using numbers or drawing you learned in school? If we divide one bread into three, four, or five persons, what part will be each person's share? How many one-thirds are there in 15 breads? What is the 'showune' of one bread?

24. If one dozen of Lexi pens costs 60 birr, what will 20 pens together cost?

ii. Khimtigna Version

ክንደጢዙ ዋቕረ

ጥወነ

“ኽምጢዙ አቀ-ህብሪል ግርየጨሸቅ ቱ ሩሄል ፅቦ እግዘኻስብዙ ኣርቕት” ይሽቶ ኣውሪል ኣጥናዞድ የን ሻ ፒ ኤች ዲ ድግሪዝ እቻዘኖ ፅሁፌል ጣቅመቁ ሚዝርጣን ኣክቨነንስ የሻ-እኒን ጣይቀነይዙ ዓለመድ፡፡ እኒን ጥናቲል ሲተፍሽርነንስቅ ሚዝየንዛሻ እግዘ-ኻስብ ጅቅ ፃየፃይሽቶ ክተሰቢል ጋጥመው ታሪክ ዊንም ዲዝሻትድ ይግስ ግቨሪስትነ ጣይቀኩን፡፡ ክኻስብድ ዋቕሬል ኣትኩርድር ነይርሽ ቀሶ ኣቐኩ፡፡ ይሰብድ ዲቁዲቁ ጣይቀኖዝመ ወሸኖዝ ኣቐንስቅ ንቕፆ ጊዜድ ክት የሻ ዊግትሮድ፡፡ ክድመድ የት ቴፐድ የን ቐዳጠ ማጥን ቓፅ ይር ዊግትርሽ ቀሶ ኣቐኩ፡፡

ዋቕርጥ

1. *ፆታ*: _____ *ዕድሜ*: ____ ምጀ ብዝረው ቄንቄድ _______ ክፍል፡-----
------
2. **ዊትርቅ እን ጣብዬል *መ* ፅብሮዳ? እን ኻግሪል *መ* አኹርሽሮድ ዊንስ ላዘ ኻግሪስ ፊልስር ተትረር የሻ? ኣው ኻግሪስ የሻ ተትሮድ?**
3. **እን ክንድሻ ሻኒል ኣውይር ክንተ ተትሩ?**
4. **እግዘ-ኻስቢል ኣወይረር የሻ/ዳህነ ፃብር ሰራሽረርመ? ዳህነ ፃብር ሰራሽረር ኣርሽ ወረኝ የሻ ክምላሰንድ?**
5. **እግዘ-ኻስቢል በጣምዝ ቀንደቁ ዊንም በጣምዝ ቀናይረቁድ ውር ውር ኟይ?**
6. **እግዘ-ኻስብድ ክንደኖድ ክግስ ቀሶ ዊንም ጣቅሞ የሻ ይር ኣምንደኩመ? ኣምነኩን ይርሽ ውርዝ? ኣምነቀር ይርሽ ውራር ኣምናር?**
7. **ክክፍሊል ፅቦ ክንሰኖ-ክንደኖ ፃኻድ ጋልፅተ ቸልደኩመ? ክፍሊል ክንደጥድ ውር የሻ ሰራሽኻድ ክንሰተድሰ ውር የሻ ሰራሾድ?**
8. **ክእግዘ ኻስብ ክንሰጥድ ክፍሊል ክንስቻንድ ክባህሊዝቁ ጎዝ ዊንም ኻስብ ጣቅምሽኻኩመ? ተክዘ ዩውር ጋልፅ፡፡**
9. **ካቅልድ ዊንም ክአቀ-ህብርድ እግዘ-ኻስብድ ኣውሽሻ የሻ ሻተሰቢል ዊንም ሻተሻኒል ስራሽኻድ/ጣቅምሽኻድ?**
10. ***ክክንደነ መፅሃፊል ፅቦ* እግዘ-ኻስብድ ክኣቅልድ ዊንም ክት ፅብሮ አቀ-ህብርድ ፃዮ/ጣቅምሾ እግዘ-ኻስቢጅቅ ሎ/ተኮ *መ* ተካው የሻ? ኣዊ የሻ ተኮድ? ተካው ይርሽ ውራቕ የሻ ተካዮድ?**
11. **ክዊትርቅዙ ቲግብሪል ዊንም ላዘ አቀ-ህብርዙ ሰቢል እግዘ-ኻስብድ ጣቅምሽር ኣርቕረርመ? ክንድሻ ሻኒስ ፍር ክኣቅሊጅቅ ሰብ ሰራሽራሻ ውር ውር እግዘ-ኻስብ ጣቅምሽር ኣርቕረር?**
12. **ክንድሻ ሻኒል ክንድረቁ እግዘ-ኻስብድ ኣውሽሻ የሻ ክሰብድ ከብስኻድ? ጋልፅ፡፡**
13. 20-(4½+6+7)
14. $3\frac{1}{2} + 5\frac{1}{3} - \frac{4}{7}$
15. 0.3x0.25
16. ½ ፤1/3 ፤1/4፤1/5፤1/8፤1/10 **ታት ክት ውር ይር የሻ ጭሻሮድ? ካቅልድ/ከቀ-ህብርድ ሰ ውር ይሻ የሻ ጭሻኻውድ?**
17. $\frac{60}{12}$x20
18. ክኘ 20 ቁርሸን ፃይስር ሱቂል ኣፃቐች ፡፡ 4.5 ቁርሸኒዝ ሽኮር፤ 6 ቁርሸኒዝ ቡን፤ 7 ቁርሸኒዝ ቆሸ ሰሙነ ጅብ ይር ኣዝች፡፡ እናይ ሸቀጥድ ጅብር በትር ዋቐ ቁርሸን ፃይር ዋጥርትር?

19. ሎው ኣርሽ ዲቆ ቻዝምረ ጊዜል ሻሲዘ ችዝሻጣኒስ $3\frac{1}{2}$ ኩንታለን ባህርመል፣ 4 ኩንታል መይለ፣ $2\frac{1}{6}$ ኩንታል ስቅም፣ $1\frac{1}{3}$ ኩንታል ዚሩ ድልምዙ። እን ቻርሽድ ጥቅለዝ ዋቐ ኩንታለን ድልምዙ?
20. ላው ሻን ኩነተ ተሲቶ ሻኒዙ ሚስርቲዙ ዋላይዙ ፍራትደ ኣርቕጠ በኑ። ሻኒዙ ሊግዝድ 0.0045 ኪ.ም፡ዊርድድ ቆሽ 0.003 ኪ.ም ኣቓሽ ሻኒዙ ፍራትድ ዋቐ ኣጡ?
21. ሽውነ የኖድ ውር የነት የሻ? እስቲ እኒት ክንድሻ ሻኒል ክንድሮይዝ (እግዝጥድ ጣቅምሽርም፣ስእልጣቅምሽርም) ቓሊሽ? ላው ኻበሽ ሻቖ አቅዝ ኣድልስሽ ውርውር ችሻጥቁ? ሲዘ አቅዝ አድልሽሽ ሳ? ኣኮ አቅዝ ሳ? 15 ቱ ሾነድ ኣው የሻ? 15 ትል ዋቐ ሾንጥ አኩዃ? 1 ቱ ሾነድ ኣው የሻ?
22. ላው ደርዘን ሌክሲ እስክርቢቶንድ 60 ቁርሽን ፊስጡ፣ 20 ሌክሲ እስክርቢቶንድ ጥቅለዝ ዋቐ ፊስንጥቁ?

ሚዝየንዘኩን!!!

Appendix F: Classroom Observation Protocol

Day: ________________________ Time: ________________

Wereda/district: _____________________ Kebele: ___________________

School:___________________________ Grade and section: _________________

The Physical Setting	
Description:	Observer Comments
Teacher activities	
✓ Use students' experience ✓ Use real world situation ✓ Engagement ✓ Accept various students' ideas ✓ Respect students' idea, questions, and contributions	Observer Comments
Student activities	
Descriptions	Observer comments
Interactions	
➢ Teacher and students ➢ Students and students ➢ Student and objects ➢ Individuals ➢ Pairs/small groups ➢ Whole group work ➢ Questioning that involves	Observer Comments
Aspects covered in the classroom	

• Purposes
• Ideas within and outside the mathematics
• Mathematical concepts in the lesson
• Connections with culture
• Connections with other content disciplines
• Contextualization
• Materials/aids used
  ✓ Cultural/indigenous
  ✓ Non indigenous
	Observer comments:

Appendix G: Workplace Observation Protocol

Case: ------------------- Wereda/district: __________ Kebele: ______
Workplace type:________________________Activity: ____________________________
Observer: -------------- Date of observation: ----------Time of observation: --------to --

Respondent: Code/Name------------------ Sex:-------- Age: -----

Time of write up or transcription (the same day): ---------------to-----------------

The Physical Setting	
Description:	Observer Comments
The Participants	
Description:	Observer Comments
Activities and Interactions	
Description:	Observer Comments
Conversation	
Description:	Observer Comments

Aims of the activity:
____

____

Appendix H: Sample of Student Written Work/solutions to mathematical tasks