CHAPTER -3

METHODOLOGY

3.1: Problem statement

The studies dealing with everyday and school mathematics indicate that there is mathematical knowledge (concepts that are used outside and in school), but that there are differences in the ways in which the knowledge/practices of this mathematical knowledge is treated in the two areas. The reviews of related research show that mathematical knowledge developed in the community/in practice is more effective than that developed in school especially in arithmetic (Nunes, 1991). And also that little is known about the qualitative nature of the learner's experience prior to school and how this informal knowledge interplays with school knowledge and the kind of knowledge that results from the contact of these two practices.

Thus, it is important to examine how children learn mathematics while participating with other people in cultural activities, and how they learn in school. The interplay between the cultural practices in the community and the school mathematics practice and the resulting nature of knowledge and the process of appropriating need to be explored in order to understand how children learn mathematics in school.

3.2: Rationale for the study

The difficulties that learners face in school mathematics appear to be as a result of changes in practices. Vygotsky distinguished this duality when he explored everyday concepts and scientific (mathematics) concepts. According to Vygotsky the more natural and elementary processes (everyday concepts) provide the necessary but not sufficient conditions for progress toward more powerful thinking tools. For Vygotsky progress in thinking involved transformation and interpenetration of more natural, spontaneous and elementary processes by the cultural, abstract, organized and mediated processes (e.g school mathematics) (Vygotsky, 1986, p.194). However connecting everyday and school mathematics concepts appear to be the challenge facing teachers and educators alike. The everyday concepts are imbued with personal meaning but are tied to concrete experiences and resist systematicity, while scientific (mathematical) concepts are systematic and general but are initially empty of personal meaning. Appropriation of the concepts cannot occur automatically – a teaching process that builds connections between
the everyday and the scientific concepts is needed (Renshaw, 1992). Further, Sfard et al
(2000) have indicated that learners difficulties encountered were due to differences in
epistemological nature of the mathematics in the two areas, the learning modes and
nature of knowledge of everyday and school mathematics is different. Learners come to
school mathematics with a limited and often a different kind of epistemological stand
point from that shared by school mathematics community. Thus, the study looking at the
everyday knowledge practices and its interface with school mathematics might assist
teachers and educators in coming up with appropriate interventions in the mathematics
classrooms.

Facilitating development of mathematics literacy in learners is one of the key tasks
facing mathematics education today. It is imperative to understand philosophical
underpinnings of the school mathematics, as with the writing of Kuhn (1962), it has
increasingly been recognized that school mathematics’ epistemology is objectivist, which
manifests itself in the teaching of mathematics as a body of objective facts. Teaching
mathematics from this objectivist stance contradicts and overlooks the human nature of
mathematics with its inherent cultural biases.

There is little knowledge about whether teachers are aware of their teaching
approaches, what epistemological position they take while teaching. Thus, a study
highlighting the epistemic practices of the interface between everyday mathematics and
school mathematical practices would help sensitize teachers to be reflective on their own
teaching approaches. Potential conflicts on differences in understanding might be
minimized if teachers and learners alike became aware of differences between their
perspectives in mathematical meanings of the objects. As Voigt (1998) has explained,
"The teacher and the students routinely arrive at mathematical meanings take-to-be-
shared without realizing all the alternative interpretations of the phenomena. In everyday
classroom life, there is a risk that these processors will degenerate into proceduralised
rules and rituals so that the students will be unable to differentiate between mathematical
inferences and the conventions of mathematisation.” (p 214)

The heuristics used by children in informal settings are often used in solving
problems in the classrooms as the tools and resources that the child uses in transforming
the original problem are familiar, routine like where some solutions may already be
available. The knowledge that children bring with them to school has a powerful influence on how they interact with the mathematical concepts and phenomena, and how they derive meanings and learn the concepts in classrooms. National Council of Teachers of Mathematics, (NCTM), 1991 has called for valuing and building on children's informal mathematics knowledge for the reform of mathematics' instruction. Often in the studies conducted in the area what has been neglected are cultural aspects of children's everyday experiences and their attitude toward mathematics. Thus, if the nature of the knowledge was known, appropriate pedagogies might be adopted which maintain and stimulate children's positive initial attitudes and beliefs.

The style in which learners provide their responses and structure their writing may be influenced by the way in which discourse is organized in their community. Also, children who are intellectually autonomous in mathematics and are aware of, and draw on their own intellectual capabilities when making mathematical decisions and judgments as they participate in these practices are likely to perform better and succeed in mathematics (Kamii, 1985, quoted in Cobb, & Yackel ., 1996). Thus, not taking into account these important cultural differences may produce inaccurate perception of the performance. Also identifying the experiences that are relevant to or representative of the cultural context of a given group of learners can be extremely difficult. Thus, knowledge of epistemological perspectives that target learner's culture might be of help.

3.3: Research Questions

The following questions guided the research:

3.3.1. Nature of common mathematical knowledge in the community

- How do children come to acquire the common mathematical knowledge of their cultural system?
- How is the knowledge held in the community?
- What is the source of the knowledge?
- How is the common mathematical knowledge used in the community?
- What is the source of common mathematical knowledge in the community?

3.3.2. Nature of the common mathematical knowledge in school

- What is the nature of the common mathematical knowledge in schools in Zambia?
- How do children come to acquire the common mathematical knowledge of the system?
- How is the knowledge held in the school?
- What is the source of the knowledge?

3.3.3. Interface between Ngoni/Tumbuka knowledge and school knowledge

- How does the mathematical knowledge of the cultural system interact with school mathematics knowledge?
- Is there an interface between out-of-school mathematics and in-school mathematics practices?
- If yes, what epistemic practice arises from the interplay?

3.4: Objectives of the Study

The study seeks an understanding of the mathematical knowledge in the community and in the school. The broad objective of the study is to examine the interrelations between the cultural system of mathematics and the school mathematics practices, focusing on the epistemological perspectives of both the knowledge systems. In other words, the study will aim at examining the nature of the mathematical knowledge, and attitudes that are acquired in the interplay of the two practices in the classrooms.

The specific objectives of the study are:
1. Investigating the mathematical ideas, concepts and knowledge embedded in the cultural activities of Ngoni/Tumbuka people.
2. Investigating the mathematical practices in school
3. Examining whether the epistemological basis of out-of-school mathematical knowledge differ from schools' mathematics
4. Examining whether there is an interface between out-of-school mathematics and school mathematics practices in classrooms. If yes, what is the nature and the extent of this interface? Does this lead to development of a new epistemic practice(s) in the Zambian schools?
3.5: Assumptions
The study assumes that the socialization patterns in the community is largely similar and that the learning opportunities for young children before going to school is, to a large extent, ‘homogeneous’.

3.6: Definition of terms

*Common mathematical knowledge:* Most cultures do not have a category called mathematics, let alone refer to some of the mathematical concepts in isolation; rather, they are integrated into the contexts in which they arise, in a complex of other ideas that surround them. These ideas and knowledge are shared by the members of the given community, and school mathematics. The apparent similarity of the everyday concepts and the school mathematical concepts enables a teacher to act toward the child as if he/she were advanced in understanding the concept than actually is the case. Thus, at times the learner and the teacher may coordinate their interactions and productively engage in teaching/learning episodes on the assumption that they have a similar understanding of the representation and yet the teacher may see the intermediate representation in abstract algebraic terms, while the child is focused on the empirical visual features of the lines (Renshaw, 1992). In the present study ‘common mathematical knowledge’ refers to these similar concepts and ideas that are discernible in the two contexts.

*Procedural talk:* In the study this has been taken to mean/focus on the discourses that refer to the steps in solving a problem.

*Conceptual talk:* This has been taken to mean/refer to discourses in which the reasons for using particular procedures to solve a problem have also become the object of conversation (Sfard et al, 1998)

*Regulatory talk:* This is non-mathematical, but helps in maintaining order and discipline in class so that learners do not deviate from the classroom discussions.

*Contextual talk:* This refers to talk/discourses that refer to the context of the mathematical problem/task.
In the study this refers to a sequence of instructions or questioning that leads to a particular ‘solution’ or teaching unit/concept, which recurs or is repeated in a given lesson. It highlights a strategy/approach to introduction of concepts, examples etc.

3.7: Nature of study

The study seeks to explore the nature of mathematics practices in the community and how this mathematical knowledge obtained in this cultural milieu interplays with the school’s mathematics. The focus of the study is the epistemological basis of these mathematical practices, that is, the interface between the nature of the knowledge forms in the two contexts; the community and the school as experienced in the school setting. Learners belong to a community and, therefore, the cultural aspects consist of the ways in which language, artifacts, activities are understood and used in the community to which participants belong. Thus in order to understand the embedded nature of learner’s understandings of common mathematical knowledge (Wertsch, 1998), the community’s’ social, economic and political life and activities are examined.

3.8: Research Design

The study utilized qualitative research methods: The qualitative research methods provided the respondents with room to offer personal accounts for their attitudes, motivations, perceptions, views and feelings, the meaning and interpretations given to events and things as well as their behaviour (Hakim, 1987). Ethnography was used and refers to the description and interpretation of phenomena that has been observed in its natural or social setting. It is well suited to the study as it is based on human interaction in natural and social settings such as community, schools, classrooms etc (Picciano, 2004). In particular focused ethnography was used to triangulate data gathered from field work observations, focus group discussions and unstructured interviews while exploring the mathematical practices in the community and in school.

3.9: Target group

3.9.1: Description of the site

The study was located in the Lundazi District of Eastern part of Zambia where the Ngoni/Tumbuka people live. The Ngoni/Tumbuka people are classified as Bantu speaking people. They fall under one traditional ruler -(Senior Chief Magodi). The area
is classified as rural (National Census data, 2000) and its main economic activity is subsistence farming. The estimated population of the area is 50,000 people. The language of the area is Tumbuka. The area was chosen through purposive sampling. The researcher is familiar with the culture and language used in the area.

3.9.2: Scope of the study

The study was designed for school going children at primary education level. The age range for the target population was 12 -13 years. It involved school going boys and girls. Further, the children's community and homes and the primary school located in these communities were part of the study.

3.9.3: Population, Sample Size and Sampling Technique

The study targeted school going children at grade six (6) levels (age range 12 – 13 years) and those in the community (pre-school) in Lundazi District of the Eastern Province of Zambia. One school named Nkunda primary school in Lundazi district was chosen for the study as this was most accessible to the researcher. It was a government school with a catchment area of 14 villages. The school was designed to have two streams, but due to shortage of teachers, one stream was maintained, but with the consequence that each Grade had not less than 50 learners in a class. An almost equal number of girls and boys were enrolled in each grade level.

The school is located about 2 Km of the village where most of the participants came from. Learners walk to and from the school. The area is rural and had a poor road network. From this school, two classes were selected for this study, one at grade one (1) level and the other at grade six (6) level. The sample included learners from the grade one class, the first ones to come into contact with school and formal mathematics. This group, however, could not verbalize their reasoning, but were important for the study, because their reactions to the first contact/encounter with formal learning provided a deeper insight into what happens when children everyday knowledge and concepts come in contact with the structured school knowledge. The grade six class at the same school was picked up for the study, and these learners (mostly twelve to thirteen year olds) were generally able to reflect and verbalize their reasoning (Piaget 1965).

Activities, games, festivals as well as business franchises in the community from where most of these children under this study come from were observed. Further, five
(5) persons in the community were interviewed extensively. These included; one parent of the children in school, one village elder, village headman, one woman and one man working in markets.

Gender was considered in the selection of the participants. An equal number of boys and girls were selected. For the persons in the community too an equal representation of the sexes was sought. The research took place over a period of five (5) months.

3.10: Data collection methods

In order to explore the nature of common mathematical knowledge in the community and in school, ethnographic methods, such as observation, focus group discussions and unstructured interviews were used. The focus was on explanations and meanings constructed by the community members, learners and teacher(s).

3.10.1: Observation

This approach involved the observation of everyday activities. In most of the cases participants were aware of the researcher. This approach was adopted both in the classroom and in the community. The interactions between learners and the teachers in classroom and the learners and the elders/peers in the community were studied in its naturalistic environment. The observations concentrated on significance, meaning and impact. Observation was important and it required familiarization with pupils in the class. Also the researcher had to find a discreet position in a corner or at the back of a classroom where the 'presence' was less visible and would not, therefore affect the events much. While written notes were taken, also an effort was made to record behaviour patterns, such as 'gestures' 'facial expressions', movements, body language in general, tone of voice etc. It involved making notes about classroom events while the schedule, time-tableing, topics etc were left to run as usual. The classroom talk was recorded verbatim and this was amplified by the other behaviour stated above. Thus, the classroom discourses were captured. A discourse in this study refers to 'a system of statements' which constructs an object (Parker, 1992, cited in Carla, 1999, p.69) encompasses behaviour, activities, values and beliefs, relating to social power and hierarchical structures; and denotes membership to particular groups (Hull & Schultz, 2001 cited in Journal of American Education, 2007, p.6).
3.10.2: **Unstructured Interviews**

"The unstructured interviews were a formal interview rather than an informal discussion. It was based on a clear plan of target issues that the interviewer sought to understand. The plan was kept in focus which guided the interview. However, the questions were general to allow the respondent maximum freedom of response" (Ratner, 2002, p. 153-154). Probing and plodding techniques were used to gather information, collaborating information, getting explanations of observed incidences/activities etc. Both teacher and the selected learners in school setting were interviewed, while in the community, only a selected elderly and those in positions of respect in the community were interviewed. Unstructured interviews were suited for gathering information that required ascertaining cultural origins, formation, characteristics, and functions of mathematical knowledge. The participants could be questioned about cultural activities, artifacts and concepts that had a direct bearing on the researcher’s interest (Ratner, 2002). Further, interviews encouraged participant(s) to describe their experiences in detail so that the researcher could comprehend cultural elements embedded within the experience.

3.10.3: **Group Discussions**

In the study the discussions were conducted with four (4) learners from the research class (Grade six). Here the researcher asked/followed up classroom 'discourses'. The learners articulated/explained some behaviours noted in the classroom as well as their general behaviours. The participants talked about home situations as well as school situations.

3.10.4: **Literature search**

Further data on the Ngoni/Tumbuka peoples was collected from libraries in Zambia.

3.10.5: **Mathematical tasks**

At school and in the community some mathematical activities and tasks were prepared and given to participants. These were followed by unstructured in-depth interviews inviting participants to verbalize or express their views on the processes on tasks/activities. Also focused group discussions with learners and interviews with the teacher were held.
3.11: Data collection procedure

In the community an ethnographic survey of the community practices and knowledge systems of the Ngoni/Tumbuka was conducted. A few activities were identified in the area which had apparent ‘mathematics’ concepts in them. A number of mathematical concepts such as circle, rectangle, diagonal, augmentation, estimation, length etc were identified in the selected activities. Not much of organization or setting up of acts was done. The cultural activities like games, weaving, crafts, agricultural practices and tools, house construction, some problem/situational tasks, number systems, riddles, buying and selling etc were observed. Observations and note taking was used to collect most of this data. As the practitioners went about doing their crafts/activities, unstructured interviews were carried out for understanding of the kind of mathematics they use in the crafts and in activities as well as the rules of the game in case of games. The data collected consisted of descriptive and reflective field notes, transcribed taped interviews and some verbal solutions to tasks.

Some of the observed activities were not everyday occurrences; they took days/weeks to finish, for example building a house. As the researcher took field notes, questions were posed to the ‘practitioners’ to explain what they were doing and how they were doing. Questions on how they acquired this knowledge and skills were asked. The interviews focused on understanding of common mathematical knowledge practices and the epistemic system in which it is rooted. Thus the following aspects were the focus of observation and questioning:

- nature of mathematical knowledge
- justification/validation of knowledge
- how knowledge was learned/transmitted
- source of knowledge

At school level, the first graders and the sixth graders were the focus. The observation of the first graders offered insights into how the first contact between school (formal) and the local community knowledge influence the classroom mathematics discourse. Unfortunately, it was difficult to engage in discussions/interviews with this group of learners (grade ones). The sixth graders on the other hand (roughly of 12 – 13 years old) were of the right age to articulate/explain what they were doing in school
mathematics and how they were using everyday knowledge in solving the classroom problems. Apart from classroom observation for the whole class, interviews and focus group discussions were held with four (4) selected class six learners.

These four learners were selected with the help of the class teacher. The learners were selected on the basis of being active participants in the class and having varied abilities in terms of class tests results and assessments by the teacher. Further, gender was considered when selecting the participants. Two girls aged 12 years were selected, while one boy was 14 years old and the other boy was 17 years old. (The boys, the researcher was told delayed in starting school as their parents wanted them to help in looking after cattle/goats. As a result, the classes did not have a homogeneous age group. Some learners were visibly older for the classes they were in). The boys and girls came from the identified research village. The whole class was observed, however, to tap the interactions between and amongst the learners and the teacher.

The identified learners were observed in their normal class. The mathematics lessons were observed, and these took place as scheduled on the time-table. As mush as possible the teacher was advised to go on as usual in his teaching. After the lesson, the identified learners were interviewed. The interviews did not happen immediately after the mathematics lesson(s) because the participants had to attend other lessons. Few sessions in the afternoons were arranged with these students. Apart from these, the identified learners were also observed outside the classroom, as they took part in play/games. The classroom observations focused on signification and meaning making processes. Noting down certain events, interviewing learners to hear their explanations and matching one event or explanation against others helped in establishing a framework for understanding.

3.12: Data analysis

The data arising from ethnographic methods such as observation, and unstructured interviews were analysed through a process of inductive data analysis (Berg, 1995) which involved identifying the concepts and processes in the different contexts/activities. The process of examining and re-examining the data was done in iterative steps, that is, field notes, interview transcriptions and problem solutions were read, re-read. As the process progressed (of iterative reading and reflection), categories
emerged (Strauss & Corbin, 1998). The body language, gestures, facial expressions were also noted, and semiotic analyses conducted.

The actions/behaviours and statements were checked/tested through identified parameters of an epistemic practice, that is whether they amounted to one or could be considered as such. The categories for an epistemic practice fell within the following areas;

- nature of mathematical knowledge
- justification/validation of knowledge
- how this knowledge is transmitted
- source of knowledge

The analysis focused on actions and statements that were probable elements or artifacts of the identified aspects/areas. In particular whether the series of actions and statements were consistent or could explain the common mathematical knowledge practices of the learners arising from their cultural upbringing or whether it was consistent with the school mathematics or were of a different system altogether.

The mathematical discourse practices were analyzed in both settings focusing on situated meaning of words (utterances), social dimensions of mathematical learning and so on. According to Moschkovich, 2006, "... learning mathematics was a discursive activity that involved participating in a community of practice... using multiple material, linguistic and social resources" (cited in Gutierrez et al, 2007, p.27). Discourse analysis included analysis of verbal language in-use and other bodily actions such as gestures, facial expressions etc.

The data collected through observations, discussions, and unstructured interviews, were synthesized using an activity theory (Cole & Engestrom, 1993; Engestrom, 1987, 2005; Leont’ev, 1978) perspective to understand better how the mathematical meanings are made in the classrooms and in the community. Using activity theory as an analytic heuristic tool helped to unravel multiple dimensions of learning (mathematical) activity (Gutierrez et al, 2007, p.4). According to cultural historical activity theory approach to learning (CHAT), the structure and development of human cognition (thinking, learning and acting) emerges through culturally mediated, historically developing activity (Cole, 1996).
Mathematical activity was seen as multimodal in nature (Gutierrez et al, 2007). In the community the cultural artifacts that mediate the learning were studied within their given epistemological systems. The belief systems in the community guided the understanding in explaining the relationships, as Ratner citing Durkhein stated that the belief systems do not only make things intelligible, but “they also prescribe the ways that things should be and the manner in which people should act to make these outcomes occur.” (Ratner, 1994, p.193)

The chapters that follow deal with the field data and analysis and discussion of the data in light of the objectives formulated in the beginning for the study. Chapter four (4) presents a detailed socio-cultural account of the Ngoni/Tumbuka people. It also deals with the epistemological basis of the community’s knowledge of mathematics. Chapter five (5) presents results of the interface between learners’ understanding of mathematical knowledge and the school’s understanding of the same. Chapter six (6) presents discussion, and conclusions and implications for the study.
The Ngonis migrated from South Africa invading the regions on the eastern part of present day Zambia. There were two main groups; Mpezeni and Mbelwa who settled
in two areas, which were not adjacent to each other. One group under the leadership of King Mbelwa was cut off physically when countries' borders were drawn during the partition of Africa, leaving the other group, Ngoni in Zambia under Magodi rule (Davies, 1971).

The Ngoni people arrived at the present location, in Zambia between 1700 – 1800 (now called Magodi) and came in contact with the Tumbuka speaking people who were the natives in that land. According to official documents, the Ngoni did not conquer the Tumbuka people as it was generally known, but, rather, the Tumbuka themselves submitted to them. Interestingly, Ngoni acquired the language of Tumbuka people and lived peacefully with them. This contact gave rise to a community which is now called Ngoni/Tumbuka community.

4.1.2: Language

There are seven major languages spoken and used in the nine (9) provinces of the country, though the language spoken is Tumbuka, English was accepted as the sole official language as back as 1964 (Zambia's Independence Year). English is the language for political pronouncements, business, school education, technology and documentation. Beside Tumbuka and English, Nyanja has a familial presence in Magodi as it is taught in school as a subject along with English. Nyanja is used as a lingua franca by more than three different communities across this province. All the school going children are exposed to this language since it belongs to the family of Bantu language, a significant number of words are common or at least similar if not the same in both Tumbuka and Nyanja languages. Therefore, the native speakers of Tumbuka, even if, are not exposed to Nyanja, can understand it partly. In the Eastern Province, Nyanja is the language taught in schools as a subject, and thus all school going children were exposed to this.

4.1.3: Brief History

The Ngoni/Tumbuka people have been at this location since migration of the 1800s. This was a period before colonialists and missionaries came to this part of the country. By then there was very little outside influence on the social, economic and political lives of these people. The social life was organised around the cycle of maize growing. The maize crop (a cereal) was the central organising feature in terms of time
for the activities. This was the staple food and each family ensured that they grew enough to last them till the next farming season. The grown ups spent their time in leisure activities after returning from farming activities. The major activities such as ceremonies and festivals took place when people harvested their crops. Apart from the festivities, men attended to other activities such as building houses, granaries, starting new fields (kusinda). Women took care of household chores apart from taking part in preparation of fields. The children aged one to four played within their compounds with their peers. They also accompanied their parents/guardians, as they undertook their activities. Among older children, boys went for hunting and setting up of traps while girls assisted their mothers and grandparents.

At this time, the economic activities were through barter system. The Ngoni/Tumbuka people did not have a currency as a medium of exchange for commodities. The community had a number of measuring instruments (mwenso) for various items or crops. The maize crop was traded in various measures depending on its state (whether fresh on the cob, shelled, unshelled or ground into flour). As an old woman explained when she was asked about how she obtained an axe, “Ngwembe zibili or zitatu, nipela mbavi ghakwana” (Three plates of maize flour was exchanged with an axe). If one requested for help in their field, payment was according to the number of lines (mizele) made and then a bucket of close to 20 litres (called ‘thini’ in the community) was given.

The Ngoni/Tumbuka did not have a written alphabet, but they utilised sticks, stones and strings to keep records. The number of herd of cattle was matched with an equivalent number of stones or sticks. According to an old woman in the village, in order to know the likely birth of a child, a woman used to tie a knot on a string for each passing moon. After eight or nine knots a baby was expected and the string became the record of the birth of the child. The women used strings for purposes of recording and keeping information while the men marked spots on a stick. Even debts were recorded this way. If one owed another three or four plates of maize (shelled), this was recorded on a stick (notches were made on it).

In 1902, the British South Africa (BSA) Company took over administrative responsibility for Northern Rhodesia (current Zambia, Gardiner, 1971). The Company
had mineral rights in this area at that time. However, the minerals were in the North of Northern Rhodesia, and, thus, the Eastern Province and the Ngoni/Tumbuka people in particular were largely unaffected by these developments. Hence the cultural practices continued in these villages. The company concentrated on the settlers (mostly Europeans in origin) in the mining areas leaving the rural areas to stagnate economically. However, the rural areas provided cheap labour for the mines without accruing the benefits of modern mining work and development.

The barter system in the community continued and existed alongside the currency introduced by the Company. The colonial office assumed direct responsibility for Northern Rhodesia in 1924, but the dual economy comprising of a relatively developed sector under European control and an undeveloped rural sector continued even after. With the introduction of hut tax, young men migrated in search of wage labour to the commercial farms, mines and factories. While the colonial administration exerted minimal influence on the social life and values of the rural community, it was the Christian mission that left a mark. In fact the missionary’s pioneers arrived well before establishment of colonial administration. These exerted an influence on the local affairs. Though their primary aim was spreading Christian faith, they passed on other features of their culture and ideology. They encouraged individualism at the expense of community’s collectivism (Gardiner, 1971).

The missionaries introduced basic literacy, new crafts (carpentry, building) and generally helped people to participate in the modern exchange economy. Over time, interaction with the outsiders has modified some aspects of the culture of the Ngoni/Tumbuka people while many traditional practices continued to exist within the Ngoni/Tumbuka community.

4.1.4: Economic activities

Men engaged in or were primarily occupied with practicing agricultural farming and, buying and selling of these products. Women too were involved in these activities along with attending to household chores, gardening, firewood collection, water fetching and so on. The community still practiced subsistence farming that conflicted less with the harmony of nature. Though they were struck with drought from time to time, causing hunger and misery, the style and the manner of farming did not change. Maize (staple
food) farming, played a big role in economic, social and recreational pattern of life of the majority of the people.

4.1.5: Power relations

The Ngoni/Tumbuka people had a centralised and hierarchical social structure, which was also patriarchal in nature. The families were closely knit together and formed the base of the hierarchy. The positions of leadership were hereditary, sons taking over from their aging parents. At the helm/apex there was the Inkosi (chief). There was a traditional court system amongst the Ngoni/Tumbuka people where customary laws (traditional laws) and the statutory laws framed by the National Assembly (Parliament) run simultaneously. Depending on the case/offence committed, or grievance one had, generally people knew where to go to get redress. The cases involving land disputes, lack of cooperation, leadership wrangles involving such position as headmanship, group headmanship, and so on, or breach of traditional customs (e.g. one not respecting the departed, or quarrelling at the funeral house) were resolved at the traditional court system (Nyumba ya Madando).

Many such cases as livestock trespassing, witchcraft allegations, disobedience to traditional authority were also resolved in the tradition court system. Similarly other cases which took place in the community for instance adultery, assault, payments of debts related to marriages divorce or default in payments of bride price. The cases involving murder or manslaughter were referred to the statutory laws (High Court System) just as cases involving Nation State System, that is, involving written contracts, title deeds, theft and civic crimes where the police were involved.

The traditional court system was a unifying aspect of the community in general. They all identified themselves by this law and respected this authority. The bringing up of the children emphasised and encouraged knowledge of the customs, hence adherence and obedience of laws of the land was demanded. Collective responsibility stemmed from this law among families and other community members.

The Ngoni/Tumbuka people have pervasive family interconnections and these are very strong. The social structures are mostly communal and favour social institutions that ensure accountability and order. Thus an individual in the community has to balance the
self-interest to collective needs, that is, sacrificing resources in accordance with institutional norms that function to maintain the kinships.

The community respected taboos, which shaped and influenced their moral beliefs, hence, behaviour, and for their basic survival, long life and quality of life. Thus, though at the surface or outwardly, the Ngoni/Tumbuka people exhibited feeble attachment to their local religious beliefs and taboos, ostensibly in favour of ‘foreign’ mostly Christian religious teachings and values, their beliefs still ran deep and controlled most of their daily lives. They tended to explain everything in terms of supernatural powers being behind most of the calamities, even, the successes of individuals. For example, those successful were ‘thought of’ as having medicines which enabled them to succeed.

Thus, the disposition/orientation of the Ngoni/Tumbuka people was to an extent influenced/linked to their ecology, record of seasons and the spiritual values. These aspects influenced their thinking and had a bearing on their decision making process. Respect for elders, for one another, for authority, collective responsibility, and respect for taboos and nature and submission to or fear of supernatural powers appeared to be the driving forces behind most of the activities/decision-making processes of the Ngoni/Tumbuka people. There was a strong kinship in the community, such that whatever one owned was seen as belonging to all.

The Ngoni/Tumbuka people still had discernible values, attitudes and behaviour though through contacts with other ethnic groups and schools where the children went, coupled with the money economy and nation-state set-up, some of their values, attitudes and behaviour were affected or eroded.

4.2: Learning Forms in the Community

In order to reflect on the nature and the structure of the knowledge of the Ngoni/Tumbuka people, the study looked at among other things their forms of learning, and how this was passed on from one generation to the next. This offered insights into their conceptualisation of knowledge, and how it was acquired. The forms of learning of their everyday life are looked at through children’s play, specialised knowledge, skills, and crafts.
4.2.1: Children play/games

The learning was fostered through children's play and games. The children played within their compounds (vicinity of the home-house) with their peers under the watchful eyes of the parents, mostly, mothers and grandparents. The play took the form of 'role play' – imitation of adult roles in life, and also creative plays such as moulding using mud, playing games, dancing and singing songs. The play involved a number of activities such as making dolls for the girls, which they strapped at their backs and mimicked their mothers or nurses on how to stop a baby crying. The boys and sometimes the girls made a wide range of toys for themselves. These included, wire cars – these were made for them by much older boys (about six to seven years old) sometimes they made similar toys, but made of clay soil for themselves. The girls tended to make 'houses' and mimicked the goings of their mothers while boys tended to imitate the fathers. Thus, through such play, children learnt some of the community's knowledge and ways of living. However, this was supplemented by other ways and opportunities.

4.2.2: Learning how to use a tool (a hoe)

The Ngoni/Tumbuka used the hoe for ploughing and preparing the fields for sowing. In the community, miniature hoes were often made for use by the children, and were invited to 'help' in preparing the field. By observing how the hoe was used by the adults, they tried it out themselves. The older siblings and the parents then offered comments of encouragement or correction, instructing them informally. "Yes, good girl, ... good boy, ... now do it like this, ... good, ... you are going to be a big farmer". In such circumstances, children 'played' with the real thing – they took part in the real activity using a tool especially designed for them.

The older boys and girls were shown how to handle a hoe when heaping the soil in order to prevent soil erosion. But this was not done at once, it happened over a long period of time. The length of the handle of the hoe also meant a particular use of the hoe. The learners observed how the adults used the hoe in the fields and at home. It was observed that the girls worked or assisted the women while the boys worked under the male folk. This is one of the dominant ways that the children learn the life skill cardinal to the Ngoni/Tumbuka's life, that is, using a hoe.
4.2.3: Other tools

In the evenings, adults, mostly grandparents, told stories to the children in their compounds. These stories or narratives were common and wide-spread in the community. Riddles were another tool for instruction amongst peers and with the adults. In a similar arrangement as for narratives, riddles were also put to each other or to the group of children present. Those that responded quickly were commended. The children also threw riddles at each other as part of play. Examples of riddles;

- Zingilila uku tikumane (Go round this way and let's meet!) Ans: bande (a belt)
- Chiziba chane chikulu, kwene somba yilimo imo (or mulamba yimo) (I have one large pond, but there is only one fish) Ans: Lilimi (a tongue in the mouth)
- Nyumba ya kwithu yilije mukhomo (Our house has no door). Ans: Sumbi (an egg)

These taught and re-enforced metaphors within the community. These also provided development of a repertoire of anecdotes for use in a speech which was usually spiced with metaphors. The children were also treated to proverbs highlighting the folly of doing some things in a particular way.

Thus, learning in the community was also through using tools such as narratives and riddles. In cases of narratives children gathered around an adult, mostly a grandmother. In the evenings, when the moon was shining and while seated around the fire, the elders, especially grand parents, told stories to their grand children. Participation was voluntary as the adults and children sat, listened, and participated in the folk stories, songs and dance. Within the folk stories, songs, wise sayings, proverbs, poems, there were messages/information for the child, for example, cautioning the children about 'telling lies' or about bravery or how to behave in a marriage or, witchcraft, etc. The stories were told repeatedly in the community. Some folk stories had songs and required responses that encouraged the children to participate in the narratives.

Also, "learning how to use a tool involves far more than could be accounted for in any set of explicit rules. The occasions and conditions for use arise directly out of the context of activities of each community that uses the tool, framed by the way members of that community see the world. The community and its viewpoint, quite as much as the tool itself, determined how a tool is used." (Brown et al 1989, p.34). In the socio-cultural
framework, the learner and the cultural tool were interconnected. Cultural tools themselves did not determine what should be done, but, they mediated learning. They provided the means by which mental action was mediated and the meanings are attached.

4.3: Learning of specialised skills

Some of the specialised knowledge and skills in the community are held by the ‘experts’ in some areas, such as building, carpentry, weaving, basket-making, honey-combing etc. Those interested in a particular area would work with the ‘expert’. The expert guides the novice through verbal instructions, which approve or discourage the novice’s move/action. In house building, for example, the novices start with assisting the builder in taking measurements and, supplying him with what he requires. They observe him at work and gradually start taking on some of his duties leading to the whole process. It is an exercise that requires interest, such that the novice has to follow the builder wherever he goes to work. It is not surprising that the skills/expertise in the ‘specialised’ areas run in the families. This is also augmented with the interest of a person. It is said that one has to have the interest (appropriate attitude). It is not uncommon to hear of incidences of a person having a skill but no interest. Assiduously practicing is yet another way of learning the skill along with observing and having hands on experience with the help of a more skillful adult.

4.4: Analysis of a Learning Situation(s)

The learning situation cases given above; children playing, using a hoe, the narratives, and building craft, provided meaning-making opportunities for learners. Drawing from Engeström’s (1999b) third generation activity theory, two cases are reflected upon in detail looking at mediating factors, rules, division of labour and community of each of the chosen learning objects.

4.4.1: Learning how to use a hoe (object)

4.4.1.1: Mediating factors

In their ongoing participation in the activity of ‘learning how to use a hoe’, there were several mediating factors in particular context(s). The mediating tools in this case were miniature hoes made for the learners, which resembled those of the grown-ups (adults). Further, to an extent the adult(s) too around the learners embodied the history and experiential world which learners interacted with. Thus, rather than the miniatures
holes alone, adults and peers also acted as the mediating tools. As Vygosky puts it, "It is through the mediation of others, through the mediation of the adult that the child undertakes activities. Absolutely everything in the behaviour of the child is merged and rooted in social relations. Thus, the child's relations with reality are from the start social relations (Vic, 1989, p.429, quoted in Daniels H, 2001, p.18). As learners interact with the object, they also interact with adults (who embody experience and history of the community).

4.4.1.2: Rules

As learners were transformed through ongoing participation in the activity, there were rules and regulations that they had to respect. For example, the hoe was not to be used to cut trees or tree stumps, but for tilling the soil. The way the hoe was handled provided yet other rules. Both hands were used to hold the handle of the hoe. Using one hand to hold the handle of the hoe was seen as improper (within the community considered a sign of laziness). These constituted the rules in the learning activity. Apart from these rules there were also norms and the regulations governing the use of the hoe related to gender. The section 4.4.1.3. looks at these.

4.4.1.3: Division of Labour

Within the community, the Ngoni/Tumbuka people were patriarchal and division of labour according to gender was the norm. The women worked together and they were assisted by the girls. The men too worked on their own. The field could be the same, but the two sexes worked separately. In the 'use of a hoe' case, the girls worked closely with their mothers or aunts, while the boys were with their fathers or uncles. Apart from the gender roles also imparting on the leaning of the object, the whole activity took place in the community. The community also had an impact on the learning of the object.

4.4.1.4: Community

The community knowledge and its values (its social, cultural and historical knowledge) impacted on the activity that is, subconsciously interacted with the learners as they transformed in their ongoing participation in activities (objects) of their community. The activity analysis could be reflected in diagrammatic form as in figure 4.4.1.
4.4.2: Children play (object)

4.4.2.1: Mediating factors

Similarly, for the learning or meaning-making process of the other objects, for example in the children play, as the children focused on the object, nursing a baby; the meaning-making process was facilitated by mediating artefacts. The children used dolls, either mud type or ones made from cloth cuttings. These were strapped on their backs as they mimicked their mothers and aunts. The dolls mediated their meaning-making process as they transformed in their ongoing participation in the play.

4.4.2.2: Division of labour

Within the play, the gender roles as obtained in the community were reflected in the activity. The girl children played with the dolls, while the boys played with wire toys. Where both sexes played together the boys assisted the girls in strapping the baby dolls on the girls' back(s). When a boy volunteered to have a doll strapped on his back; the rest of the children laughed. It was not appropriate; they had not seen it in the community before. The gender roles as they existed in the community were reflected in the process of learning some aspects of 'motherhood'.
4.4.2.3: Rules

The children were bound by some basic rules, such as; they were not allowed to play away from their compounds, the dolls were not to be put face down, but up right, the dolls also were not to be dropped, but handled with loving care etc. The children played under the watchful eyes of the parents, especially mothers and grandmothers. The parents or guardians did not stop their everyday chores, however, in order to watch the children, they performed their daily chores at the same time.

4.4.2.4: Community

The Ngoni/Tumbuka people provided the context. The community’s values were extended to the learners as they imitated the adults in their play. Every adult in the community was expected to be available for the children, giving them advice wherever appropriate.

However, though the model suggests, the activity happens/takes place in isolation, that is, as a stand alone and complete in itself, that is not the case, as learners interact with the objects (learning situation), there are other learning situations or activity systems that either directly or tangentially interact with the highlighted activity system. In the given case, learners come across of or were exposed to information about good soils by the adults, how to heap soils for a particular crop using the hoe, or how to prevent soil erosion etc. As Engestrom himself puts it, “... usually there isn’t a singular activity system, it is a network of activity, and thus we explore object-oriented cooperative activity of several actions, but focusing on tools, and means of construction of boundary objects in concrete work processes” (Engestrom, 1999; p.7)

The model could be appear like in fig.2 below but noting that the activity system is in motion and not linear. As the learning situations are not exactly the same, and also the mediating tools may not be the same as learners move/transform to potentially shared or jointly constructed object, Engestrom(1999).
The learning situation (object) has different forms in relation to the learner as Engestrom has explains, "The object of the activity system is a moving target, not reducible to conscious short-term goals" (Engestrom, 1999b, quoted in Daniels, 2001, p.91)

Thus, the learning situations, the people involved, the context, the time all varied as learners transformed in their ongoing participation in the community of practice. All the learning was contingent upon several factors but within the Ngoni/Tumbuka socio-cultural environment. Further, the learning or activity systems took place within the epistemological framework of the knowledge of the people. The practices; vis-à-vis handling of knowledge, its justification, how it was learned and its source, all fitted into a particular epistemological approach to knowledge. The sections below focus on this aspect.

4.5: Analysis of bases of learning

There are a number of aspects of epistemic practices discernible in ways of learning in the community, as there was no one fixed method. The section below focuses on these as reflected in the learning situations above.
Learning in the community involved learners/children being in the situations or context or taking part in an activity. For example when learners sat listening to stories (narratives) by elders, they were in the situation or context for learning. Whatever message/teaching was in the narrative, was picked up. Learners were immersed in the practices of the community without necessarily aiming to learn something. The learning was mostly spontaneous, and unplanned.

At other times learners took part in the activity as a way of deliberately learning. When young learners (children) used their miniature hoes to ‘help’ in tilling the land, they learnt by doing. Learners observed their parents/guardians using the hoe in the field. The learners were keen and interested. As they played with the miniature hoes, they picked up the basics, such that by the time they came to the real hoe, they knew what to do. The learners got feedback on how well they were performing through results of their work or through encouraging comments from parents/guardians. The learners first observed what was going on, (How the hoe was used by the adults) then as they felt ready they attempted or imitated the action.

Some knowledge in the community was held by a few members, who could be referred to as ‘experts’. These had the preserve of the skills that were not common to all. The skills needed one to devote time, effort, and practice to learn them. The builder for example, held ‘expert’ knowledge of how to build a house. They achieved this knowledge through painstaking dedication, assiduous practice and effort over a consideration length of time. To obtain the skill a person worked under an expert for a length of time. In the building skill, novices observed and later took part in tasks that were part of the building process. They worked under the watchful eyes of the ‘expert builder’, who gradually gave them tasks depending on the level of competence reached. The expert in some instances made verbal comments on the task’s quality or condition, but largely novices self-corrected themselves as they observed the expert’s work.

The learning itself was chaotic in a sense. The learners made errors and repeated the acts in order to conform to some acceptable standard or way. Learning how to ‘use a hoe’, for example, had children play with the hoe, first with miniature type of hoes and then later graduated to the real hoe. In the process of learning, they went through trial
and error at their own time. The adults around them were not particularly concerned about the errors, as it was recognised as part of process towards learning.

Learning in the community, thus, did not generally take place during one event or context. It took place over a period of time, in different contexts and in the company of different people or activity. In case of learning to use a hoe it took months and in some cases years. Learning to become an expert (say in building) depended on the novice’s pace. Each learner learnt at his own time. There was no time requirement, as even as the children played with the dolls, mimicking their mothers and grandmothers; it was a process which did not have a fixed time.

4.6: Nature of Knowledge

In the community, the forms of learning highlighted the nature of knowledge. The knowledge was in the social and practical activities of the people. Though there was no set curriculum or subjects areas, the community’s goals and expectations guided the rhythm of learning. The context played a large role in shaping/determining the practice/concept produced and also how this social aspect manifested itself. The various practices situated in particular contexts involved psychological tools/artefacts.

For example, the way the community looked at ‘time’ attests to the nature of knowledge and its structure, that is, its clarity and determinateness in terms of use and coherence in difference contexts and within the people.

4.6.1: Time

It was observed that within the country the months or times of a year were grouped into three categories/bands; - the rain season, the cold season and the dry/hot season. This corresponded directly with what was happening naturally. The time for each event in the community was known; when to start a new field, (ku sinda), when to move a village to a new site (nyengo ya chihanya!) – if there was need etc.

Also how the sun (solar day) set or how it made the shadows was yet another way of reckoning with the time of the year or day in case of the sun’s shadow. The moon also provided information on months, supplemented by many natural occurrences around them like some mushroom appearing in the bush or certain birds appearing on the horizon.
Time provided a framework in which events took place or were marked on this continuum. As one member of the village said, “Ngati tachelwa ngeti, ka tamalizyanga ndankhe kulya sima” (We are not late, we are first eating our food -sima). Time was rarely a constraint as long as there was light of day and the event fitted into the frame. However, depending on activity or urgency of the activity or matter, the members knew how to react quickly. When a statement to the effect that “Lutani muka weleko lubilo lubilo –mata pajani” (“Go and come back as quickly as possible –saliva on a leaf”) was uttered, it indicated the urgency. The ‘mata pajani’ meant before the saliva dries on the leaf, one should be back or the activity should be completed. It was an expression that invoked serious urgency and calling of or abandonment of any other activity to respond to the request. Saliva was not actually spit on a leaf, but from folk tradition, if one delayed and let the saliva dry on a leaf, they died instantly. Thus, presently, it was an expression in the given language indicating how urgently/quickly one would want something done. Besides, it provides a framework (not exact time) that is the one responding to the request had to gauge how long to take in the manner of, estimating or taking into account how long ‘saliva’ would take to dry on a leaf.

Time helped to set the schedule of the people, so that there was coordination. The natural phenomena or their recurrent activities could be referred to or ordered in terms of duration, through the same concept. The growing of the staple food (maize) helped coordinate the yearly activities of the community. This was related to natural events especially crops, planting time or onset of cold or hot season, flowering of certain trees, harvesting time and so on.

Time offered a framework or means by which people allotted events of periodical in nature. For example, the Zengani ceremony takes place every year after people have harvested their crops. Thus, it functions as a scheduler of events – coordinating the activities of individuals within their culture. Also, the function of time as a tool for ordering the events, for example, whether past or in the future or before or after a stated activity was also highlighted.

The knowledge was in relationships between and among phenomena. The nature of knowledge was in resonance with the forms of learning within the community. Thus, the knowledge in the community had a close relationship to its objects, that is, the
practical situations in which it was shaped, used and applied. It was social, in the sense that it served a social purpose and it was consistent with people’s values, beliefs and attitudes.

4.7: Justification of knowledge in the community

The Ngoni/Tumbuka people believed that the best time for planting the maize crop was during the first rains. Over the years, it had shown that the harvest was good when the crop was planted at that time. One old man explained, “Para mvula yoyamba unda gome chaa mbwenu wa chelwa. Kweni para wuli na fataleza, unga yezyako. (When one does not plant with the first rains, then one is late unless s/he will use fertilizer, s/he might achieve something).” Asked how he or the community came to know that, he explained that, from experience and what his parents and grandparents told him, it was working. Planting the crop at this time alone, however, was not enough, the community also knew that they had to get rid of weeds and air-let the ridges, at an appropriate time. The old man further explained that, “Tose tikumanya! Nchakumanyikwa kwa waliyose munda wukwenela kulimiba, dulu chaa!” (Everyone knows, it is well known knowledge to all that a field should be ploughed, weeds should be removed).

The community adhered to the pattern as it was able to satisfy or to give them the results. From their point of view their knowledge of maize growing was adequate and acceptable.

The Ngoni/Tumbuka have a distinct type of basket attributable only to them. The basket makers were asked about why they stick to a particular way of making baskets. One craftsman explained, “Kwa asibweni ndiko nkhasambilila ntheni ntheni ndimo baka chitilanga” (I learnt the skill from my uncle and this is how he was doing it). The baskets were made in a particular way, varying in only details of decorations, style and size. The way the men started making the baskets; the preparation of the materials (reeds) from the swampy river, preparation of the strings etc was similar amongst all of them involved in the craft. From the discussion with them, they all obtained their skills from observations of others. The other members of the community and others bought their wares from elsewhere. Their wares were widely accepted and they adhered to their pattern of basket making.
The Ngoni/Tumbuka's verification (justification) of knowledge was dependant on achieving the desired results. The knowledge of maize farming was justified in the sense that adherence to it brought about a good yield. It was, thus, accepted within the community. Similarly practical knowledge was warranted through performance or demonstration. Also when members of the community purchased the baskets, it gave a nod of approval of the product, and hence, the knowledge of making it. Greeting knowledge's justification too depended on the consistent correct use and serving the community for its social etiquette. The utility of the knowledge and the community's acceptance and adherence to it warranted its continued use.

Thus, justification of the knowledge be it social or practical was achieved through its observed regularity and conformity to the community's expectations. The practical knowledge was largely warranted through demonstration of the skill or presentation of the product and its acceptability, within the community. This tallies with what Ernest found that the validity of tacit knowledge was demonstrated by the individual's successful participation in some social activity or form of life, while practical know-how was warranted through public performance and demonstration (Ernest, 1998).

Summary

The nature of the knowledge in the community was in social and practical activities. It was held in context of particular experiences. It was closely related to the artifacts and situations in which it was developed and applied. The tacit knowledge was influenced by the people's history as most of it was passed down from earlier generations.

Informal means of learning were utilised to pass the knowledge from one generation to the next. As the community's knowledge was in the context of particular experiences, social situations and practical activities provided the learning environment. The children learnt in an informal way, this happened either through exposure to the learning situation, through observing, imitating what adults or peers were doing and later, when ready, participating in it or through involvement in the learning (activity), for example, when children participated in activities such as tilling the land in the fields using hoes or through interaction with the learning situation. The social situations provided the learning environment. The social situation mediated the 'knowledge' to be
learnt or meaning making process. And further, different situations, contexts re-enforced the learning as learners were transformed in their ongoing participation in the community of practice.

The justification for the knowledge was through the community’s acceptance of the knowledge in as far as it served and was demonstrated to the wider audience. The source of knowledge was the elders, artifacts and the ‘experts’ in the community.

The chapter has so far explored the social and physical practices, and an epistemological basis for the knowledge and its methods and procedures of the Ngoni/Tumbuka people. However, of concern to the overall study is how mathematical knowledge is held, how it is passed on from one generation to the next and whether it has different sources or means of justification. The next section of the chapter addresses these issues.

PART B
4.8: Ngoni/Tumbuka Number system and numeracy Practices
4.8.1: Number system

The Ngoni/Tumbuka basic number system utilises the numbers 1 to 5, that is ‘chimozi’ (one), ‘Vibili’ (Two), ‘Vitatu’ (Three), ‘vinai’ (four) and ‘vinkondi’ (five). Then the number system adds on from five (5) up to ten (10). Thus six (6) is ‘vinkondi na chimoza’ (meaning five add one). It is a base five number system. Ten becomes the new referent point for the numbers thereafter between ten (10) and hundred (100), though still using the base numbers 1 up to 5. For example, twenty-one (21) is ‘makhumi ya bili na chimoza’ (two tens plus one).

There is a uniform and consistent pattern in how the numbers are generated from 6 to 9, from 11 to 14, from 16 to 19 and so on. Table 4.8.1 shows the pattern of the numbers.

<table>
<thead>
<tr>
<th></th>
<th>One</th>
<th>Chimoza</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Two</td>
<td>Vibili</td>
</tr>
<tr>
<td>3</td>
<td>Three</td>
<td>Vitatu</td>
</tr>
<tr>
<td>4</td>
<td>Four</td>
<td>Vinai</td>
</tr>
<tr>
<td>5</td>
<td>Five</td>
<td>Vinkondi</td>
</tr>
<tr>
<td></td>
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<tr>
<td>---</td>
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<td>---</td>
</tr>
</tbody>
</table>
| 6 | Six | Vinkondi na chimoza  
    |    | five plus one  |
| 7 | Seven | Vinkondi na vibili  
     |    | five plus two  |
| 8 | Eight | Vinkondi na vitatu  
     |    | five plus three  |
| 9 | Nine | Vinkondi na vinai  
     |    | five plus four  |
| 10 | Ten | Khumi  |
| 11 | Eleven | Khumi na chimoza  
     |    | ten plus one  |
|   |   |   |
| 16 | Sixteen | Khumi Vinkondi na Chimoza  
       |    | ten plus five plus one  |
|   |   |   |
| 20 | Twenty | Makhumi ya bili  
       |    | Two tens  |
| 21 | Twenty-one | Makhumi ya bili na chimoza  
       |    | Two tens plus one  |
| .26............ | Twenty-six | Makhumi yabili chinkodi na chimoza  |
| 30 | Thirty | Makhumi ya tatu  
       |    | Three tens  |
|   |   |   |
| 37 | Thirty-seven | Makhumi ya tatu na Vinkondi na vibili  
       |    | Three tens plus five plus two  |
| 100 | hundred | Makhumi khumi  
       |    | ten tens  |
|   |   |   |
| 1000 | Thousand | Vikwi  |
|   |   |   |
| 1000000 | Million | Vikwi Vikwi  
         |    | thousand thousand  |
|   |   |   |
|   | Very large numbers | Kauteka  
         |    | countless (grass/-sand)  |
The community does not have the number ‘zero’. The zero is conceptualised as ‘palije’ meaning empty (not there). The large numbers are conceptualised as ‘countless’ more like grass or sand where one would lose count. As one person puts it, “Aah, vikwi-vikwi, vikwi-vikwi, munthu wangafikako uko kupenda, mbwenu ndikutu wabundisyenge”. (Aah million! million! would a person reach that far in counting without making a mistake?)

The number system has been replaced by the school one for the majority of the people in the community. The elderly, however, still use Tumbuka number system. Section 4.8.2 below looks at uses or applications of the number system.

4.8.2: Numeracy practices

4.8.2.1: Counting

Counting in the community is accompanied by gestures. Kamoza (one) is accompanied by a raised forefinger. Tubili (two) is shown by two raised fingers and so on, till four. Five (chinkondi) is shown as a clenched fist. Then six (chinkodi na chimoza -5 + 1) is shown by a clenched fist and one finger from the free hand to indicate six. Seven through to nine are demonstrated the same way. Ten (Khumi) is shown by putting together the two fists. The numbers between ten and twenty follow the pattern established for numbers below ten, thus, learners as well as practitioners keep a record of the ‘tens’ mentally in order for them not to loose count. The children are instructed in the counting and sense of numbers in the community as the conversation between mother and child shows.

Mother: Nipeko mango imoza (give me one mango) [mother also raised her forefinger indicating one] The child picks a mango and gives it to the mother.

Mother: Zikomo, mwana muwemi (Thank you, good child) “Sono nitoleleniko mbale zitatu (Now give me three plates) [Mother also shows the sign for three, she raises three fingers for the child to see] The child picks one plate and takes it to the mother. The mother protests (as she raises her three fingers again) protesting that she asked for three, but the child goes back and picks one more plate. She goes again and brings one more plate.
The mother uses both verbal and finger gestures to bring home what is meant by ‘imoza’, ‘zitatu’. Within the community counting and reference to numbers is ‘confirmed’ or re-enforced by the finger gestures. During the second ‘task’, the mother mistakes the child’s effort thinking the child would bring all three plates at the same time. The child, however, brings the three plates one at a time.

The counting usually goes with use of the fingers and hands and in some instances, objects are used, for example, stones, sticks, fruits, songs/rhymes, bean-seeds, riddles and so on. For numbers 1 to 9, fingers are used. For the number ten, fingers and palms folded together indicate a ten. When this is done twice, it means 20; three times means 30 and so on. A combination of this sign symbol for ten and the fingers demonstrates any number up to 100. Since no formal written symbols are used, all calculations with numbers are mentally done and sometimes with help of some aids, either drawn on the ground or items manipulated with hands. The results are communicated either verbally or through these signs.

The community is responsible for this knowledge and they have a way of checking or ensuring that it is maintained. The conversation below further attests to how the knowledge is held, checked and passed on. (Sara is a 56 years old woman from the research village).

R: How did you know how to count?
Sara: Bapapi na banyithu (through our parents and our friends)
R: What about them, where did they learn from?
Sara: Katose tiku khalilana, nabo bakaba nabapapi bawo. (We live in a community, they also had parents)
R: How do you know you have made a mistake in counting?
Sara: Banyako bakuphalilenge (Your friends will tell you)
R: How important is it to have knowledge of these numbers?
Sara: Eeh? Ka sono mungapulikana wuli na banyako? Pakuti vyose vintu khupendeselana, izi zindalama nitheula pela. Eeh kandiwo umoyo! [Shows surprise at the question] (So how would one agree or work with his/her friends? Because almost everything requires things to be counted, even money needs to be counted, it’s really about life!)
It is the responsibility of the community starting from parents, friends and the large community to impart mathematical knowledge to the novices and also to check its usage. This is a strait that is, indispensable in life. When she was asked about the importance of the numbers she showed surprise at the question, as to her knowledge of quantification and counting was all about life.

Tumbuka number names in counting and numeracy practices are slowly being replaced by the school terms. Children and the youth prefer to count in the conventional ‘formal school’ way despite the fact that the Tumbuka language has its own equivalent of the number terms. The influence of the school mathematics and also the missionary education through money economy has become part of the number system and numeration. Nyimba (not real name) a young man in his 20s who has never been to school was able to count nails that the researcher gave him.

R: Sono iyi mizumali njilinga? (How many nails are here?)
Nyimba: [started picking them in pairs as he was counting; two, four, six, eight,] Thirteen!
R: Count again!
[He recounted, again grouping them in twos up to five then one remained] Eleven!
Nyimba: Nangu budisya paku yamba! (I made a mistake during the first count.)
[He was given more nails to count. This time they were fourteen in number. He again grouped them in twos as he counted and found answer fourteen.]
R: Why are you counting in groups of two?
Nyimba: Ndipo nkupenda lubilo (That’s when I count fast)

In counting, Nyimba was able to frame a situation in terms of a more collective unit, he was counting in twos thus he was to think about both the aggregate and the individual items that composed the numbers. As Lamon, puts it, “When a child counts on his or her fingers and begins to substitute the counting word five for the fingers on one hand, the child has adopted a more powerful grouping technique; likewise, when a child counts on from the first number in an addition problem or counts by tens, we can interpret the strategy as an indication of higher level conceptual organisation” (Lamon, 1995, p.171).
Thus, within the community the number system is linked to counting of objects or fingers on the hands. The five fingers on the hand are the basic base system for counting and sense of numbers. In their practices, be it money transactions or quantification of things, the direct counting of objects/items is utilised. The organising feature is one of object counting or removing some. Even when the arithmetic operations are extended beyond addition and subtraction to division and multiplication, the community’s ways are still in form of ‘counting on’ and removing some, that is, adding objects or removing some. This is not however divorced from the contexts in which it arises. As no formal (written) symbols are used, these calculations do not take place in isolation or on paper. It is done mentally or with help of objects/items and followed up practically as they resolve tasks/problems in their community. The teaching of number and numeration was also through number rhymes as section 4.8.2.2 below shows.

4.8.2.2: Number rhymes

Learning of number and counting is also through number rhymes. The number rhyme presented below involved some actions by participants as they took part in the song rhyme.

- Kamoza, kabili, katatu, kanayi – Mee! Mee! yenda! X 3 (one, two, three, four – Mee! Mee! walk forward while counting up to four! (repeat 3 times)
- Kankondi na katatu Mee! Mee! Khala X 3 (Eight Mee! Mee! – sit down) (repeat three times)
- Khumi na kabili Mee! Mee! jumpha X 3 (Twelve Mee! Mee! Jump) (repeat three times)

The number rhymes teach numbers, especially counting, but apart from that aspect, they also provide the children with fun. In the first rhymes, as children walk forward as they count and when they reach four, they chant in unison “Mee!, Mee!”. This is sometimes accompanied with a dance routine. In the second one, the children count up to eight as they ‘sit and stand’, interspersing their count with “Mee! Mee!” Similarly for the last rhyme, children count up to twelve and jump as they chant “Mee! Mee!”. They then repeat the task three times. The children choose the numbers to count. The children also learn counting through play/games as section 4.8.2.3 shows.
4.8.2.3: Simple algorithms

The children play a game known as Kapele (also referred to as big number). A player bounces a ball on his leg, keeping it afloat, while at the same time, counting. With each kick on the ball, a count is made, ‘kamoza, kabili, katatu, kanai, chinkondi, chinkondi na chimoza, ‘na katatu, nakanai, khumi, khumi na kamoza (one, two, three, four, five, six, ... eight, nine, ten, eleven ) and so on, until the ball slips and falls on the ground. The players take turns. The winner is the one who reaches the highest number in counting.

The other common game is ‘Phada’ which is played by both sexes, but it is popular amongst girls. A player hops on one leg as s/he leaps in each of the boxes. (see fig 4.8.1)

As the player hops, she also counts till s/he reaches the circular enclosure at the top. This is a basic move which everyone including the youngest ones try. As the play progresses, a box is given a value, for example two, then the player has to bear in mind that s/he has to count in twos. The other variation is that they ask a player to land on two feet, but with a leg each in the adjacent boxes. The count too has to double. For example, if a player starts at ‘level 1’, the count goes as follows; two, six, eight, twelve, fourteen, eighteen. Then on the way back, the player has to subtract, and thus the count will be 14, 12, 8, 6, and 2. The values in the boxes are changed as players take turns to see who will fail first.
The other numeracy practices are depicted in the buying and selling activities, section 4.8.2.4 highlights some of these.

4.8.2.4: Buying and selling

The elderly and many who have not been to school still prefer barter system to obtain their requirements. The surplus food items are traded for clothes, soap and salt. For example, three tins of maize of about 12 Kg each (there is a bucket that is used as a standard measure) would be exchanged for 2 Kg of course salt. This varies according to the time of the year; when the maize is scarce only one and half bucket is exchanged for a 2 Kg packet of salt.

Otherwise the commonest way nowadays of buying and selling is through money. The excerpts below highlight some of the practices. The researcher found a six year old girl selling bananas as instructed by her mother. She carried her merchandise in a basket and moved around the village and the nearby school selling her wares. The bananas she was selling were in heaps of four.

Excerpt: 4.8.1

R: How much is one banana?
Girl: Tugulisa inoza inoza yayi, kweni four in 300 Kwacha (We are not selling one by one, we sell four for K300)

R: If I were to buy one, how much would it cost?
Girl: Ngeti nginga gulisa yayi! (I would not sell!) [At this point the girl wanted to leave and continue her business]

R: Okay, give us these, 5 heaps... how much?
Girl: [She remained quiet for sometime, then she counted on her fingers and said] ‘One five’ [The exchange rate between the Us dollar and the Zambian Kwacha at the time of research was K3,500 per 1 US $ (dollar). When dealing with the local currency, people usually ignore the last two zeros and refer only to the figures in front. “One five” means, One Thousand Five Hundred Kwacha K1500/-]

R: [She was given K2000/-] How much is my change?
Girl: [after a short while she said] Five ngeti? (Five is it?? meaning K500 is it?)

The girl knew how to sell only the ‘packed’ items. She was matching the four bananas against the K300. She had not thought about how much one banana would cost.
She did not entertain the idea that she could sell one, it was not in her mind. She handled the transaction well, by counting on. Thus, instead of multiplying 5 by 300, she added up the K300 to find ‘one-five’, that is, K1,500.

Adults apart from practicing barter system also transact using money. The excerpt .... highlights the practice. A middle aged man was selling a 50 Kg bag of maize. We approached him to find out how much he charged for 10 Kg of the same. His name is Gwepu.

**Excerpt 4.8.2**

R: How much is a full bag?
Gwepu: Mutengo wa boma in 38 Pini (The government recommended price is 38 Thousand Kwacha (K38,000)- Pini is colloquial referring to a ‘thousand’ in terms of money in Zambia)
R: We need just 10 Kilo, how much will that be?
Gwepu: [He fidgets] 10 Kilos! [he becomes quiet but he is seen counting or doing some arithmetic] 8 Pini!
R: Not 7 Pini?
Gwepu: Yayi, ndiko kuti nipangenge losi... 8 yili makora! (No, then I will lose, 8,000 is ok)
R: How do you arrive at 8 Pini?
Gwepu: Chifukwa hafu ni 25 Kilos, ninshi ndalama in 19 Pini. Hafuso ni ‘twelve five’ mbwenu ndalama ni “nine five”, mbwenu 10 kilos yikwenela kuba kuma 8 Pini. Ipo kasi gulani Twelve na half kilos, Tingabilana waka! (Because half is 25 Kg then in terms of money it comes to K19, 000. Then if halved again then it becomes twelve and half and money will be K9, 500. Now 10 Kg should be around K8, 000. I think you buy twelve and half – or we might steal from each other)

Mr. Gwepu is forced to sell his bag of maize at the government recommended price of K38, 000 per bag. This forces him to deal with not so convenient numbers when handling requests of small amounts of maize from his bag. He is familiar and conversant with the everyday fractions of half, half of half (quarter) which he handles well, but has difficulties when it comes to other fractions. He does not think of the cost of a kilogram.
of maize; he is not comfortable with other kilograms that does not fall in the 'half of half of half - pattern. He thus, resorts to estimation, rough guesses, but ensures that he does not lose. Thus, although he is dealing with money and definite figures and numbers, he still deals with them as if they are not exact amounts, but within 'give and take', a few Kwachas or Kilograms above the normal.

Riddles are yet another avenue where numeracy practices manifest themselves, section 4.8.2.5 below gives an example.

4.8.2.5: Riddles

Riddles are also an avenue for utilizing mathematical concepts in the Ngoni/Tumbuka community. A riddle very common in the community is about a goat (Mbuzi), Cassava leaves (mani ya chikhawu) and a leopard (Nyalumbwe) and a man (munthu) wishing to go to the other side of a river. The boat to be used, however can only take one item besides the man. The dilemma for the man is that the goat cannot be left alone with the leopard, and the goat with the cassava leaves, unguarded. The challenge is how the man takes them across the river? Zalvasky (1973) also reports of the same riddle amongst the Kpelle children of Liberia.

The solution is provided as follows;

- Leopard and cassava leaves are left behind as the man takes the goat with him across the river.
- The man rows the boat back alone and picks cassava leaves and takes them across to where he left the goat.
- The man leaves the cassava leaves and takes the goat with him back to the other side where the leopard is.
- At this end he leaves the goat, and picks the leopard and rows to where he left the cassava leaves.
- He leaves the leopard with the cassava leaves and then rows back alone to where the goat remained.
- The man picks up the goat and takes it across to where the leopard and the cassava leaves are, completing the riddle.

The riddle has double functionality of exercising the children's logical thinking, and also exercising some aspect of strategizing. Children have to find a suitable route or
procedure to save the cassava leaves from the goat as well as the goat from the leopard. Children have to find a logical way to see all three ‘things’ safely across to the other side of the river. The plausibility of the solution is checked against the safety of the cassava leaves and/or the goat.

In order to explore further the numeracy practices in the community, some tasks in local context were given to both school going children and the non-school going in the community. Section 4.8.2.6 presents what was found.

**4.8.2.6: Other everyday tasks**

The tasks below were given to members of the village who have not been to school to find out how they would resolve them. The same tasks were also given to grade six learners later. The tasks were set in a context that all understood. The figure 4.8.2 shows the tasks.

Figure 4.8.2: Task on legs of goats

<table>
<thead>
<tr>
<th>a) Para pali malundi makhumu ya bili na vinai, ndiko kuti mbuzi zilipo zilinga? (If there are twenty-four (24) legs of goats, how many goats are there?)</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) Para muchibaya muli mbuzi na nkuku. Sono mwana wa penda malundi wasanga 34 malundi pamoza. Sono mwana wabonaso kuti nkuku zilimo zitatu. Ndikokuti mbuzi zilimo zilinga muchibaya? (If in a goat pen there were goats and chickens and a child counted the legs and found that there were 34 legs altogether. The child noticed that there were three (3) chickens in the lot. Then how many goats were there?)</td>
</tr>
</tbody>
</table>

The members of the village Luka and the other Chimbomi (not real names) attempted the two tasks the following way. Luka got some pieces of sticks (we were seated outside in his compound) and he started counting. He counted up to four, then threw a stick on the ground, then counted on up to eight and threw another stick on the ground. He continued to do this till his count reached 24. Then he picked the sticks on the ground, counted them and announced his answer. The researcher talked to him afterwards;

R: What do these sticks represent? – What are they for?
Luka: Ka mbuzi yili na malundi ya nai, sono ndiko kuti apa, iyi ni mbuzi imoza, pala napenda four, sono kuti urike pa 24, mbwenu ndiku kuti mbuzi zakwana six. (because a goat has four legs, then it means that when I count four, then it is one goat, now to reach 24, then there are six goats) [after counting the sticks on the ground]

Luka uses sticks to represent his 'goats'; he counts in groups of four, each stick to stand for four legs of a goat. With each multiple of four a stick is dropped, and since there are six (6) sticks on the ground, and hence he resolves that there were six (6) goats altogether. Chimbomi uses a similar strategy. In his case, he draws lines on the ground as he counts in groups of four and makes a mark (a line) with his foot on the ground. When he reaches 24 he counts the marks he has made on the ground.

Luka isn't so successful in the second problem. Only after prompting him, does he obtain the correct answer. His approach is similar to the first task. The mistake he makes is to over look the fact that a chicken has two legs. With the error arising from this he proceeds as before counting in groups of four and putting sticks on the ground only to realize that a chicken has two legs. In his solution he removes three (3) legs as if removing three chickens, and proceeds to find the number of goats in the goat-pen where there were 31 legs remaining. He is visibly disappointed with himself.

A grade six learner who incidentally had learnt formally the division algorithm, approaches the two tasks the same way as the villagers. Excerpt 4.8.3 below demonstrates this:

**Excerpt 4.8.3**

R: “Given that there are 24 legs of goats, how many goats are there?
Learner: [...]silence… She was silently calculating... after three to four minutes]
sikisi goats! (six goats!)
R: How did you find that?
Learner: I worked it out ... a goat has four legs, it means, 1, 2, 3, 4, (1 goat), 5, 6, 7, 8 (2 goats), 9, 10, 11, 12 (3 goats), 13, 14, 15, 16 (4 goats), 17, 18, 19, 20 (5 goats), 21, 22, 23, 24 (6 goats!)
R: What if there were 40 legs of goats – how many goats would there be?
Learner: [The learner worked silently then said] 9 goats!
[but heard whispering, 1, 2, 3, 4, 1, 5, 6, 7, 8, 2 ...... and so on gets mixed up. Starting all over again. ... Looks at the researcher anxiously.]

R: No! 40 legs!

Learner: [The learner again became silent and then announced] 10!

The learner utilises the same method, counting and grouping the figures in groups of four. She makes mistakes and after being prompted by the researcher she counts on till 40. She announced at the end that there were 10 goats.

In the second scenario, the researcher increased the number of legs to 40 to try to ‘push’ the learner to ‘think of’ or switch to learnt short methods in the classroom, but it did not work. The learners did not ‘notice’ that the problem could be solved by the learnt division algorithm from their classrooms. Thus, instinctively or intuitively the commonly held knowledge of the community is used. In the excerpt ..., the learner is asked about the division algorithm at school. When the learner was asked if they had learnt division in class, she responded in the affirmative. When asked why she did not use the division algorithm, she could not proceed. When she was reminded that it should not be difficult, she explained that she could not remember the procedure.

Excerpt 4.8.4

R: Have you learnt division in class?
Learner: Yes we did.
R: Why don’t you use the division algorithm then?
Learner: [she tries to work it out, but failed] ... 4? I don’t know!
R: But you have done division in class
Learner: Aah, I can’t remember!

There are some differences between Luka and Chimbomi and the grade six girl, in their approach to the task. Their mental representations are conceptualized differently. Mistakes, however, do happen in either case while making calculations. The grade six girl mentally keep the answers as she works, getting mixed up in the process. While Luka and Chimbomi uses marks on the ground or physical objects to achieve the same purpose. Otherwise the basic strategy used is the same. The knowledge of the solution has a close relationship with the situation, the practical situation, in which it is shaped.
This is true for school learners as well as the local members of the village. Even when the school girl attempts the second task, the solution adopted takes a similar pattern.

The second task was attempted correctly by the school girl with prompts as the excerpt 4.8.5 reveals;

**Excerpt 4.8.5**

R: When there are three chickens, how many legs are there?

Learner: 6!

R: Then how many goats are there?

Learner: [There was silence as she counted, ... whispering to herself .. using fingers, and she finally found 28 legs remaining after removing ‘the legs of the chickens. then she continues as before counting] 1, 2, 3, 4, (1), 5, 6, 7, 8 (2) ... ... ... 28 (7) zikabapo ‘7’! (there were ‘seven’!)

R: How do you know your answer is correct?

Learner: Ka yimoza malundi ghali four, mbwenu zibili ni eight, zitatu ni twelve, zinai ni sixteen, zinkondi ni twenty, zili six ni twenty-four, mbwenu zili seven ni twenty-eight (For one, has four legs, two goats will have eight, three will have twelve, four will have sixteen, five will have twenty, six will have twenty-four, then seven will have twenty-eight).

[At this stage she was looking at the researcher searchingly for assurance/approval for her answer.]

Learner: Asi thene ka? (That’s correct right?) Ndiyo iyi! (This is the one).

R: Yes, it’s correct!

Though with just a slight variation in the task as chickens are brought into the picture she works it out taking into account the number of chickens in the lot. According to her method, it was basically grouping the numbers in fours and counting on. Unsure of herself she looks at the researcher eagerly for help or feedback and she gets assurance, she beams with happiness and she asks for more tasks of a similar nature.

The solution pattern remains close to the practical situation and the girl enjoys the experience as she identifies or works with familiar context. The concepts encountered in the number and numeracy practices above are similar to the school type, though there are different practices in the two settings.
Section 4.9 looks at the Ngoni/Tumbuka practices in measurements

4.9: Measurements

The Ngoni/Tumbuka people handle measurements, be it linear or circular or capacity in their everyday activities existing in their environment. Different locally invented standards of measuring tools are in use for common understanding of measures. The measures offer a general acceptable guide; otherwise estimation forms a guiding principle.

4.9.1: Circular measurements

When constructing circular houses (huts) or granaries a peg 'nailed' on the ground tied to a string or rope (made out of some fiber of a tree) is used to take measurements. A circumference with a 'measured' radius of a rope is drawn with the peg forming the centre of the circle. Once this is in place, holes are dug around following the locus of the peg (circumference). Poles are inserted in the holes, making a round wall. Depending on the size and strength of the tree poles used, the house might need a supporting pole in the middle or none at all. Where a pole in the centre supports the 'roof', there is reduction in the room size, but it is believed that the hut lasts longer if there is a pole in the middle. For the hut where is no pole in the middle to support the roof, the roof wholly rests on the circular wall. Its centre of gravity nonetheless acts on the position of the centre of the hut.

Fig 4.9.1: Round hut
Further, the angles the rafters make with the wall depend on many factors availability of
grass, length of the pole and the size of the house. Within the community it is said that
what is crucial ultimately is that the hut does not leak during the rainy season, thus, the
angle at which the rafters rest on the wall has to be ‘right’. Estimation is one of the key
skill that practitioners use in the measurements of angles.

The builder was later asked how he took measurements and the response was less
precise as the excerpt 4.9.1 reveals;

**Excerpt 4.9.1**

R: Kupima ndiko manyi mukupima wuli? (How do you take measurements?)
Ans: Tikumanya, para wabeka wukumanya kuti apa saizi yikwenela kuba apa olo
nthene. (We know, we just look and we can tell that, here it needs to be
somewhere here)
R: How long will this take to finish?
Ans: Malinga vose vilipo, two days, kweni nyengo zinandi panyake three days. (If
everything required is here, it will take two or three days.)
R: How come all the houses, circular or rectangular look similar?
Ans: Nyumba za makuni zo gonamo, mbwenu m’nyamata wakwenda or kupima
nthangalalo zitatu. Nipela tikutola nyozi kutola mupimo wenewula.(For round
houses for sleeping in, we use an average person to take measurements. He makes
three steps, which forms the radius which we use.) [Nthangalalo was about 1m]
R: The same person is used all the time?
Ans: Yayi, yayi malinga ngwa musinkhu na utali ngee in Yosefe, mbwenu. (No,
No, as long as a person is of average size and height like Joseph, then it is ok.)

He explained that over time he could tell the required measurements. When asked
about how long it would take to complete the job, he explained that it depended on the
materials for the job. If everything was there, it would take two to three days. Estimation
is the major tool in use by the expert builder. The estimates are verified by use of
‘known’ or already constructed items/units. A rope is usually used to take measurements.
For the houses/huts measurements are known, in terms of how many steps an average
built male should take. The length covered is then ‘measured’ by a rope and is used as
the radius in cases of huts (round houses). For rectangular houses, similarly an average male measures the lengths with his feet, putting them next to each other according to the required number of times. A rope is then placed over the covered distance and then this measured length is then taken and used either as length or width of the house or room.

The hut construction process utilized concepts of radius; circumference, angles, properties of triangles, centre of gravity etc. The measurements of the huts are remarkably consistent which can be inferred from the similar looking huts in terms of their size and design. Thus, though the measurements are not standardized they serve the purpose. The expert builder has the image of the final structure and has skills of use of tools, and ways of checking out possibilities.

This knowledge is passed on from one generation to the next, as the excerpt 4.9.2 shows;

Excerpt 4.9.2
R: How did you learn how to do this?
Ans: Bapapi, tika bekelelanga para baku zenga. Uyu naye panyake waku tolapo chimo! (We used to watch our parents when they were building, like this boy here he may also be picking up one or two things)

The expert builder thus explains how he learnt the skill by observing his parents, and acknowledges that his son present with him is also learning. The son was assisting him where-ever possible. The 4 years boy assists his father with materials he needs, sometimes even before the father asks. He is likewise involved in the building process.

4.9.2: Measurement of land

Land measurements in the community utilizes counting of ridges (mizele) or takes some unit of land (ndima) to fathom the size. The conversation with an old man in the village highlights this.

Excerpt 4.9.3
R: How do you know the size of the ndima?
Old man: Tikumanya, kufuma pano mupaka na mula musi wa chikhuni cha mutondo na mula muchibvati, ninshi ndima ya munthu yumoza. (We know from here up to where that tree is (mutondo) and up to that shrub (chibvati), then that should be enough piece of land for one person to till.)
R: Do you measure or you just estimate if so on what basis?

Old man: Kufuma pano ni nthangalalo makumi yatatu, ya munthu wa msinkho nthana, kufumaso pala mupaka mu chibvati nthaula pela. (From here it is 30 steps of an average man and similarly we count steps up to that shrub) Para mumunda muli mizele, tikupenda mizele, tikupendelana mizele. (If the garden/field has ridges, we count the ridges.)

The measurements are not precise; the area of land to be tilled is merely estimated to what is understood to be a ndima; give and take. Even where an attempt is made to measure, any average man is asked to take his normal steps, 30 times in one direction and another in a direction perpendicular to the first. Ndima for two persons means double the piece of land. (Ndima refers to a piece of land that one person is likely to till normally in order to get payment of one plate of maize flour.)

4.9.3: Measurement of capacity

Measurement of capacity is handled by using various tools (measures/containers) depending of items for sale or for exchange. In the community, measurements takes many forms depending on the commodity to be measured or shared or sold. The plates food vary in for capacity, though there is an element of standardization. As a woman (Khetase) selling at the temporal market located near the school reveals in excerpt 4.9.4

Excerpt 4.9.4

R: How much is this heap of beans?
Khetase: Apa ni ‘two pin five’ mbale imoza (Here, it is K2,500 per plate)
R: Is the plate the same all over?
Khetase: Mbale ziku pambana nako, banyake mbale yikubako yikulu. Kweni kale kukaba ‘ngwembe’ iyo bose baka sebezesyanga. Sono lelo yayi. Chili kwa abo wugula, kusankha uko mbale jikulu. (The plates in use differ, some are slightly bigger. In the past there used to be ‘ngwembe’ (wooden plate made locally) and everyone selling used this plate, but nowadays no. It is up to those buying to select or choose where they think the plate is bigger.) [The plates in use were commercially produced, they were either plastic or metal and the sizes and depth differed depending on the company that made them].
For beans or any grain transactions a plate is used to measure it. The size of the plate varies but is generally a known measure and thus most people know what that measure of one or two or more plates of beans means. The community does not particularly insist on standard measuring instruments, however in some instances it is resorted to. A good example in the community where a standardized measure is used was at the grinding mill. A graduated stick (see figure 4.9.2) is used in a bucket that is also acceptable.

Figure 4.9.2: Container for measuring shelled maize for grinding and a measuring stick.

![Figure 4.9.2: Container for measuring shelled maize for grinding and a measuring stick.](image)

Whatever amount of maize one takes for grinding, it is poured into the 'measuring bucket' and if the bucket is not full, a measuring stick is dipped into the bucket to check the level and the charges are made accordingly.

Other measurements relate to construction of houses and other structures in the community. We look at the mathematics and the nature of knowledge in these structures.

4.10: House construction

In this village the construction of a rectangular house, is performed by an expert builder, though he is assisted by the owners of the house and his special assistants. The researcher observed the beginning of the construction of one house. The area where the house was to be built was cleared and leveled up, then the team set to work. After the expert builder made an assessment of the area, he put one peg on the ground, and then according to his estimate of the required size of the house, he took the measurements. Putting his feet next to each other in a 'straight line' he counted the number of feet one,
two, three up to fourteen. A second peg was put (nailed to the ground) then in another straight line in a perpendicular direction to the first line he walked counting 10 feet. A third peg was put. In another perpendicular direction (supposedly parallel to the first line) another 14 feet were counted. A fourth peg was put. (see figure 4.10.1)

Figure 4.10.1: Foundation measurements for a rectangular house

A rectangular shape was achieved, though not accurate. Basically, the length was 14 feet and the width 10 feet. A rope was used to try to get straight lines. The assistant builder drew the lines connecting the four pegs. (The builder had never been to a formal school. His assistant went up to second grade. There were four men, three of them assisting the expert builder. Two were referred to as 'daka' boys (These were bringing mixed soil for the builder and his assistant to build the structure with) the assistant helped taking measurements, construction and in almost everything that the builder did/required.)

The builder uses his feet as a unit of measure. The rope is another item they use to make measurements with as they prepare for the construction of a house. Though it initially appears rudimentary, but the expert builder knows exactly the size of the house and how it will be after construction. As the measurements were taken, the expert was asked some questions; (R: researcher, Nyirenda: expert builder)

Excerpt 4.10.1

R: How do you know the lines will be straight?
Nyirenda: Just wait, you will see
R: But the corners won't be straight?
Nyirenda: You just remain silent and observe, you will see later.

(insert diagram)

The expert builder can not explain how the lines were going to be straight even after prodding by the researcher. All he knows is that the lines will be straight and the researcher needed only to observe and remain silent.

At that point Nyirenda, the expert builder, started 'measuring' the diagonal pegs. A longer rope was used for that purpose. (see figure 4.10.2)

Figure 4.10.2: Foundation of rectangular house showing diagonals

The dotted line represented the longer rope. This length was 'checked' against the other diagonal. When the two were not equal, the peg was moved to a position that achieved parity and consequently the lines joining the pegs were redrawn. The resulting shape was a rectangular shape with four right angles and straight sides. The researcher again asked the Nyirenda some questions, excerpt 4.10.2 highlights the conversation.

**Excerpt 4.10.2**

R: Why are you measuring between the two extreme pegs? You have done this to this side and that side?

Nyirenda: We would like to achieve equal angles or corners – we would like to have ‘sharp corners’

R: You mean when these two long lines are equal the ‘corners’ become sharp?
Nyirenda: Nyumba yikuba yo nyoroka chomene, kukubevwe kubenda, vimati vyose mbwenu ni waka selele! (The house becomes very straight, it has no bends. All the walls will be smooth and straight)

R: How did you know how to build?

Nyirenda: Nkhakhala chomene na Sibweni. A Sibweni baka manganga nyumba mu fedulo na bazungu. (I stayed for a long time with my uncle. My uncle used to build houses with white men during the federal government period)

R: So by doing this (using diagonals) you get straight lines?

Nyirenda: Namwe mwaona, mwajionela mweka! (You can see, you have seen for yourself!)

When asked why he was taking measures between two extreme pegs, Nyirenda the expert builder explained that he wanted to get/obtain ‘equal angles’ or ‘sharp corners’. Pressed further to explain the reasoning behind the measuring the diagonals of the building pegs, did not yield a direct answer. Instead he explained about the resulting end product – the house, that it will have smooth and straight walls. Asked how he obtained the skill (know how), he explained that he worked with his uncle, who worked for white men during the colonial government period. When asked further why he measured diagonals of the laid pegs to achieve a rectangular shape with straight lines –he could not explain, only to refer the researcher to the resulting structure on the ground. The mental image of the completed work, guided the activities.

Basically, the builder is not able to explain how that it happens, but has the knowledge, which appears to come from experience of working on similar tasks. The consistency achieved appears to stem from disciplined principle based on learnt ‘rules of practice’. The esteem and expectations of the other members of the community demand a lot of responsibility from the builder. The builders and those who work closely with them have the basic mathematical idea of a rectangle having two equal diagonals, two pairs of sides, with the opposite sides being equal.

The builder, like the other helper around him know the trade, the skills needed to build/measure often getting shapes that are to the satisfaction of the clients in the community. The knowledge is passed down from his uncle to himself. The builder uses
estimates, in many instances he is able to control variables, and the measurements fitted in the mental imagery of the final product. The order of occurrence of the procedure is also important. He uses it to establish a particular pattern and it is part of his knowledge of building.

Thus, the specialized knowledge (in this case practical knowledge) is held by the builder(s) who are responsible for it, and owe it to the rest of the community. Also, the burden of its validity lies with them. They were responsible for its nurture and development, though the practitioners appears not to think about the development of their work. They have a sense of the work/tasks and the practical realities of it; the time required, the materials needed, and in which order, community’s expectations etc.

The other area where mathematical knowledge is prevalent in the community is in shapes and patterns.

4.11: Shapes and Form/Patterns
In order to examine the knowledge of shapes and patterns in the community, mats, baskets, wooden walking sticks, chairs, molded pots etc were studied. A number of mathematical concepts are inherent in the motifs and artifacts. The figures 4.11.1 show pictures of a basket-bowl, a basket and a chair.

Figure 4.11.1: Pictures of basket-bowl, chair and a basket

Basket-bowl

Chair
Basket makers come up with a pattern which is repeated. The decoration is considered good when the pattern repeats itself uniformly on the completed basket. For example in figure 4.11.1, the pattern of the ‘coloured’ strands has to be repeated uniformly. The basket makers determine when to repeat the pattern. In the basket-bowl making, the coil type basket is bound closely together by the thread stitches. Different colours of the threads make the basket have different colours. The decoration of the basket is done as the coil is being made. Though the coil itself looks like concentric circles, it does not have rotational symmetry.

For example, Deliwe, one woman who makes and decorates, the baskets was interviewed on how she manages to obtain the decorative patterns on the basket-bowl. The excerpt below highlights how the knowledge was held/used.

**Excerpt 4.11.1**

R: How do you know you are now to start decorating?

Deliwe: Tikupenda na kubona, na kumanyaso ukulu wachihengo icho chukhumbika. (we count, we see, we also consider the required final size of the basket-bowl (chihengo)

R: How do you measure these distances between successive coloured parts?

Deliwe: Tiku beka waka (we just see) - estimation)

Deliwe explained that she has a final picture of the expected basket and using estimation she comes up with the desired pattern(s). She further explained that when to begin the pattern depended on the size of the bowl.
The men working on a chair were asked some questions. The patterns they were making on the back of the chair has some straight edges and slanting lines.

R: How do you get these straight edges?
Banda: You draw the line, then you follow this line till, these two meet. ..... like this, like this (He was demonstrating how it was done)
R: But some of these are not very straight so you make the lines thicker?
He shook his head in agreement.

A man in his late forties was asked how he obtained straight edges on the chair(s) (the decorations). He could not explain exactly how, but demonstrated how it was done to the researcher. The knowledge held is concretely in practice and communicated mostly through action rather than verbally, or otherwise. The practitioners know the situations, circumstances and social contexts when to apply their expertise.

**Excerpt: 4.11.2**

R: How did you learn how to do this?
Banda: I learnt from my grandparents.
R: Is it just you?
Banda: Aah, women don't know, men make the stools, and chairs
R: but the clay pots are decorated
Banda: yes they decorate their clay pots or baskets, but we use different methods to decorate our work.

The practitioner explains that he learnt from his uncle and the men in the group learnt how to make stools and chairs. But where women decorated their wares, they used clay soil or threads. The shapes and patterns on the chairs are done in neat straight lines or circular lines achieving many geometric shapes. As noted above, practitioners find it difficult to explain the knowledge or their expertise, but easier to demonstrate the skill instead.

The games are yet another area where mathematics practices of the community manifest itself. In section 4.12 below we look at one game which is popular in the community.