Chapter Six - 6

DISCUSSION AND CONCLUSION

The present study sought to examine the epistemology of the re-contextualised mathematics discourse that result from an interface between the everyday system of mathematics and the school mathematics practices. There were two parts to the research process; an ethnographic study of the everyday system of mathematical knowledge of the Ngoni/Tumbuka people and a study of the school mathematical practices.

The present chapter discusses the results given in the previous two chapters, concludes and gives implications and future directions for future research. The discussion follows the themes as outlined in the objectives; first the cultural context and practices of everyday mathematics discourse in the community are discussed, secondly the school arrangements and practices are discussed. The later was undertaken with an objective of examining home mathematics.

6.1. Social, economic arrangements and mathematics ideas of the Ngoni/Tumbuka

6.1.1: Social Organisation

The Ngoni/Tumbuka people were hierarchically organised, with their Royal Highness at the apex and the individual common man in a village house at the tail end. This authority structure was well established and was patriarchal in nature. The family structure further entrenched the authority structure. The social structures were mostly communal and promoted collective responsibility. An individual in the community had to balance self-interest to collective needs.

This authority structure was supported and maintained by the local judicial system. It was also a unifying aspect of the community. The people identified themselves with this law and respected this authority line. The children were brought up in this system which emphasised and encouraged respecting the customs, and adherence and obedience to the laws of the land. The young children respected and obeyed this structure and its consequent source of knowledge and guidance. The other aspect that influenced the lives of the people and less visible, but very influential was the spiritual values.
6.1.2: Economic activities

The community largely engaged in farming and the buying and selling of these agricultural products. The farming especially of the staple food maize shaped and provided the framework for ‘time’ and its use. It also contributed to families remaining closely knit as they supported each other in the production of these crops. Agricultural products were in some instances exchanged (barter system) with the ‘manufactured goods’ such as clothes, salt etc especially by the elderly in the community. Otherwise the money (local currency) was used for buying and selling.

The economic activities were the major contact point with other cultures which influenced the people’s way of life especially in mathematical practices. The community that predominantly used barter system was now largely using money for buying and selling of their agricultural and other products. The money economy brought with it particular ways of transacting that were not there before.

6.1.3: Learning practices

The Ngoni/Tumbuka people with its authority structure ensured preservation and continuity of its customs and traditions. The social institutions in the community vis-à-vis hierarchical authority system, traditional law system, the kinship system etc offered supportive institutions for associative learning of their community knowledge. The knowledge the children gained was held subconsciously. The learners were unaware that they held such knowledge (it was culturally engrained), it was shaped by the social context in which they lived. It was largely informally done, as learners were immersed in the cultural activities, they participated through use of cultural tools and engaged with cultural institutions. This happened through learners participating in games, plays and skills related activities. As the children played, they were always under the watchful eyes/observance of the adults around. The adult’s authority was experienced in situations and activities that learners engaged/participated in. The adults narrated the stories, led in the skilled activities, and so on and thus, respect for authority (and elders) within the community and amongst individuals was something that learners picked up as they participated in the community activities. Elders and adults or seniors were respected and held the knowledge and thus the responsibility of ensuring continuity of the cultural norms.
6.1.4: Nature of Knowledge

The Ngoni/Tumbuka people did not per se have a laid out curriculum for learners to follow, nonetheless, the community's goals and hence responsibility to the learners (young ones) were to ensure continuity and its survival of the community. The social, economic and even the political set-up (attributes) was sustained, and passed on from one generation to the next. In this set up, the context played a large role in determining the concept(s). As the results indicated (see Chapter 4), the knowledge was in the social as well as the practical activities of the people.

The nature of knowledge was such that it was held 'actively' in practice. It was practical, in action, in behaviours and in active relation to the world of practice. It was simply put 'the way of doing things' and the way things were done was influenced or shaped by tools within the community and belief system. The myths/belief system that the community practiced ingrained in them a particular 'thought' style –or cultural episteme (Foucault, 1970) that is, systems of thought and knowledge governed by rules that operated unconsciously in individuals.

6.1.5: Mathematics practices in the community

People in the community often used the objects and events directly in their reasoning, or put in another way, the objects and events mediated their meaning –making processes. Examples in different settings and situations will elaborate these points.

Number system

The number system was held in the discursive practices of the community and the learners learnt it informally within their communities supported by social and institutional supports provided therein. For example the finger/hand gestures were part of the language facilitating the learning of number system. Just as the language in use was adequate for their life activities, so was the mathematical/arithmetic number (system). The knowledge was in the 'way of doing things'.

Even for a task that was given to both groups; the members of the village who were not in school and the school going children, the tasks were attempted the same way. For example, for the task, "If there are twenty-four legs of goats in a goat pen, how many goats are in the pen?" The solution utilised by the participants involved objects and taking cognisance of the whole problem setting and requirements. The everyday
knowledge, ways of knowing were applied to resolve the task. The members from the village used sticks to count, to count on, and to structure the problem. Though no actual goats were provided, the participants while resolving the tasks did not lose sight of this picture. As one participant answered when asked what the sticks stood for. He said, “... because a goat has four legs, then it means that when I count four, then it is one goat ...” The sticks were just aids to the solution of the task. Even the school going learners attempted the task the same way, their actions were intimately connected with objects and events.

**Measurements**

Even in measurements, a similar picture was apparent, the focus for the members was on the goals of the activity- that is -seeing the task or job to its conclusion. The measures did not stand out as an activity on their own right rather they were a means to an end. They were ‘the way of doing things’ in such circumstances. Thus, in the construction of circular houses (huts) or granaries, the circumference was measured using a rope drawn with a peg forming the centre of the circle.

The straight lines and any other linear measures were made for a particular purpose, and acceptable (common) body parts, forming units of measure were used. Similarly measures of capacity varied according to the commodity being measured. The staple cereal crop (maize) had several measuring instruments depending on its state, whether still on the cob or already shelled. Thus, for the people in the community the measures did not particularly come out singularly, but were directly liked to contexts and the people’s goals and experiences.

**Building activity**

The expert builder constructed a house(s) in a similar way depending on the specifications of the owner(s). The consistency was achieved from disciplined principle based on learnt ‘rules of practice’. There was a particular product that the community expected and that placed a lot of responsibility on the builder. Again, this knowledge was held subconsciously. When the builder was asked to explain, he could not explain it. He chose to just demonstrate how it was done rather than explain the procedure. The builder focussed on the end product, the knowledge was held in concrete embodiment and communicated mostly through action rather than verbally.
Time

Time was yet another area where the nature of the knowledge in the community manifested itself. It was generally associated with occurrences in the people’s environment. For example the year was marked off by the various stages of production/farming of the staple cereal crop (maize). The time for planting, time for tendering the crop, time for first fresh maize, time for harvesting etc. Thus, for members in the community time was a guide to location/start of activities a framework for understanding the rhythm of activities, be it social, economic or political.

As in other activities where mathematical knowledge manifested the nature of knowledge was in practice –in action-. The focus was on the activities, and members knew how to inform each other about an activity, when it would take place or when it took place, selecting appropriate markers as reference points in their locality.

In Games

Even in games the nature of mathematical knowledge was held similarly. The games provided a pass-time, but also enabled participants to engage in ideas, and activities that exercised their minds towards some pleasurable goal. The rules of the game provided the how to, but the practical principles reflected the personal dimension of practical knowledge. Thus, the rules were basic, but participants applied some agency/reasoning as they applied the rules while playing the game. As participants engaged in mental activities of planning, reorganising, strategising to outwit each other, the objects (artefacts) provided the base, the thinking tools, mediating tools. These coupled with the framework or the rules of the game provided the boundaries within which participants acted.

Thus, the Ngoni/Tumbuka people did not refer to the knowledge they held as anything tangible or with content, but used and applied it in their everyday life. For the most part it was not articulated in words, but it was brought to bear spontaneously, routinely and to an extent unconsciously on their activities, tasks games etc. Though the practitioners appeared not to think about the development of their work or its content they had a sense of it, the practical realities of it. They knew about the time requirement, the materials needed, the order in which the activity would be carried out, the how to go
about it (procedure), the clients' requirements (limits), and also the community's expectation of them (ethics) and so on.

It was as a result of this knowledge that they were able to come up with consistent practice. This knowledge grew out of experience and it enabled or guided them on the course of action to take each time an event or task was required to be done. Basically there were rules, and principles which community members followed/applied, and these were coupled with templates/images of the action/structure of form they were working on.

The community's belief system remained the organising framework for understanding and for meaning-making process. As the people went about their daily chores or work, the subconscious mind played out meanings for them. Thus for a learner or member of the community to count or arrange some objects or engage in an argument, they had to display dialogues or actions that were coherent with what they believed fitted the cultural accepted knowledge forms of their community.

The nature of knowledge when mathematised was found to be the type that had direct relations between the empirical phenomena and the numerals. In the number system for example counting was through direct reference to fingers or other objects in the environment and thus, when the problem of number of goats in the goat-pen arose, the solution involved reducing or linking the numerals to empirical phenomena. Through direct tallying the sticks (standing in for goat(s)) with numerals, the learners (participants) resolved the task.

Similarly when handling measurements, be it linear circular or capacity, the objects involved tallying with the numerals coupled with visual picture (the expected final diagram or project). The participants worked with the empirical phenomena, utilising measures such as sticks or bowls without in some instances involving numerals. Also in the case of the expert builder's knowledge, it was in the concrete form of the activity of building, where numerals were involved, they were directly related to the empirical aspects they stemmed from. The pattern was the same in other observed activities such as 'time' and games.
6.2: Social arrangements and mathematical practices in school

6.2.1: Social context/arrangement

School brought together all learners of a uniform age (age group) who progressed by grades in a year. The learners were housed in different classrooms, while the teachers had their own room (staff room). The school had ten (10) members of staff. The school was hierarchically organised, with the headmaster at the helm. The headmaster was assisted by the deputy head teacher and three senior teachers. The school has captains and prefects appointed among learners drawn from those in the final grade (Grade nine) of primary education. In each class, there is a class monitor or monitoress.

6.2.2: Learning practices

The teaching-learning approaches in mathematics classroom were characterised by the teacher working generally from the front of the class. The chalkboard was used extensively, showing the steps required in a given algorithm. The elaboration was done on the board. The discussion with learners focused on what was written on the board. The teacher led the discussion through questioning and probing. Learners responded either individually or they chorused the answers. In general the written text on the board provided the basis for dialogue between the teacher and the learners. The procedure/algorithm and the general rules for solving certain mathematical problems/task were emphasised as they were displayed or shown on the board. The entire discourse was based on the work on the board. The learners observed and took in the steps as they resolved the tasks. And further since most of the symbols being used were new to the learners, and thus the board provided an opportunity for learners to them, also for the procedures and the algorithms to be shown.

The new concepts were dependant on the previous concepts, - without knowledge of the previous concepts or objects, a learner would have difficulties comprehending the new set of rules or procedures. The knowledge was hierarchically arranged and it did not require concrete embodiments. For example in order to appropriate ‘highest common factor’ of two or more given numbers, learners had to first come up with factors of the numbers given then list the common factors ones and then finally pick the highest figure(s) out of the common factors. The entire problem was manipulated through pen and paper as the teacher instructed the learners along the development of the concept(s).
The teacher presented the concepts to be learnt in suitable packages for learners to be able to grasp easily. He explained what the learners were expected to do in order to carry out the sums. The learners on their part were expected to search for patterns or remember the procedures from previous lessons or follow the teacher’s current explanation or procedure. The teacher took complete control of the learners’ learning process. The dialogue was largely between the teacher and the learners as a group. There was little between and amongst the learners themselves (see chapter 5 lessons 5.3.1, 5.3.2, and 5.3.3)

As a result of the approaches adopted, what came out of the mathematical knowledge in school was that, it had no immediate uses in the community. The concepts were dealt with as contents and procedures and this was the only aspect learners saw as ‘mathematics’. The content and procedures had their own internal consistency. The teaching projected the subject knowledge as self-contained that required no human intervention in its ways. The teacher and others as well as the textbooks had to find ways of unpacking this knowledge to the learners. The learners had no way of figuring out what else was there other than through their teacher and others who had passed through the system. As the teaching did not link the knowledge to everyday life, the source of mathematical knowledge in school was the teacher. The mathematical knowledge was what teachers taught and it was found in textbooks. The mathematical knowledge which had content (subject matter) in school determined how the task would be performed; its logic dictated how the task would be performed.

Further, the content/concepts were largely theoretical and dwelt more on hypothetical situations. Also its standard of accuracy in its procedures and operations were unique.


6.3.1: Social Organisation

The social set up and organization of learning in school was different from the community. The school, however, was located in the community (and not in a vacuum) that is, some of the aspects of community’s social relations and ways of doing some things were similar to both settings. The school environment was characteristically different from what the learners were used too. The practices in the school set up
included: organized learning sequences of identified topics or concepts, one teacher, (who was source of knowledge), social rules regarding behaviour in class and in school generally curtailed freedom of choice of learning situations, scheduled learning, use of pens and paper, bunching of learners in one group, having tests and examinations etc.

As a result of these differences the first contact with school for learners began with appropriate introduction to social and academic skills and modulus-operandi of the school. The school sought to initiate learners into appropriate ways of behaviour believed to be necessary for the new practice. Learners were initiated into the 'new' value system and the academic practices of the school.

6.3.2: Power relations

In terms of power relations the scenario was not different in the two set-ups. In the community as well as in school the adult-child relationship was one of master - submission type, with threats of sanctions or punishment for non- compliance. Teachers held authority at two levels; as adults and as people with the source of common mathematical knowledge for the learners. As adults, teachers assumed the role of parents and or guardians for the learners and also of elders in the community. Within the Ngoni/Tumbuka tradition, adults (elders) wielded authority and power over the minors (children). The teachers thus had authority and power derived from the community's expectations and also being the sole custodian of knowledge in the school. In the school, the teachers were the major source of mathematical knowledge and again like their counterparts in the community; the 'experts' in specialised skilled activities e.g. weaving, carpentry, building etc they were held in high esteem and respected. The learners were thus not under strange authority, but familiar type, though this time around it carried a different punishment or control system. The teacher projected himself as a father figure, taking full control of the academic and social skills of the learners. The learners too saw him in the same light, feeling dependent on him.

6.3.3: Pedagogic aspects

In the community (see Chapter 4 section 4.6) the learning practices were very informal. Importantly the learners were immersed in the context and participated as and when they were ready. Largely they were not compelled to learn anything, but the community expectations, the setting (environment) ensured that if one was going to be a
member of the community, they strived to learn so that they became full communicant members of the community. There was no set time for learning, nor was there a particular method of learning. The community (elders, adults, peers) were available assisting wherever possible. The community’s tools also mediated the learning or meaning-making processes.

The learning was spontaneous, subconsciously and yet in other instances it was ‘guided’ by elders or peers, but still in an informal manner. In case of specialised knowledge, learners were guided by experts in the skill and this did not take place at once. It took as long as the learners were able to take or learn. Learning in the community 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.

At school the teacher was at the centre of the learning process, he introduced the rules/procedures of the common mathematical knowledge to the learners, using the board extensively. He supported the learners and gave them adequate examples to follow (see chapter 5, section 5.3.1, 5.3.2, 5.3.3). The routines and procedures were repeated daily/weekly depending on response from the learners. From the learners’ point of view, they were willing participants, motivated and appropriately obedient to follow what the teacher said. Learners complied, as the teacher was the custodian of knowledge. Learners transformed through their ongoing participation in the activities, improving in their participation, as the practice had its own motivational structures, such as praise from the teacher or the system, rewards, ticks in the exercise books, promise of better things to come and so on, which learners cherished.

As a result the classroom practice did not constitute the ‘community of learners’ as articulated for a well designed community of learners where learners, teachers engage in integrated projects of intrinsic interest to members, often working together, Rogoff (2003). Nonetheless, a particular practice was in place and within this practice learners transformed through their ongoing participation in the classroom activities.

What was drastic in change was the type of signs and symbols in use in the classrooms. Further, the nature of the mathematical knowledge in the two contexts or practices was different.
6.3.4: Nature of mathematical knowledge

In the community their theory of knowledge, was such that it was integrated in practice, that is, held in activities. The nature of their knowledge was practical, relevant to their lives and was designed towards a tangible/immediate goal. This was directly linked to the kinds of activities the people participated in or undertook in the community. Thus, the learners came to school with a particular orientation, or background to ways of looking at knowledge. The epistemological basis of their knowledge was (directly) related to empirical phenomena. For example the number concepts were related to materials be it physical or body parts. Learners (everyday knowledge) of handling number concepts involved physical realities or direct one-to-one correspondence of these. As for geometrical concepts, these were related to physical space and so on. Thus, the nature of knowledge in the community was in the relationships between and among phenomena (see chapter 4, section 4.7). It had a close relationship to its objects, it was in the practical situations in which it was shaped, used and applied. It was in social interactions, consistent with people's values, beliefs and attitudes. It was justified through observed regularity and conformity to community's expectations. Bernstein (1999) has referred to this knowledge as having horizontal discourse. According to Bernstein this horizontal knowledge structure is not translatable, instead it has its own criteria for legitimate texts and the speakers of this knowledge become specialised and excluding.

The nature of the mathematical knowledge as taught in school had aspects that exhibited points of departure from the local (informal) use/knowledge. The mathematical knowledge in school was presented as having 'content' and 'procedures' and this was also highlighted in the presentation/outline of the curriculum. Also the content/concepts of the mathematical knowledge in school had a characteristic way of appearing to exist in its own right and could be manipulated without reference/recourse to everyday life. The content and procedures had their own internal consistency. The teaching projected the subject knowledge as self-contained that required no human intervention in its ways. The teacher and others as well as the textbooks found ways of unpacking this knowledge to the learners. The learners did not have a way of figuring out what else was there to be learnt other than through their teacher and others who had passed through the system. As
the teaching did not link the knowledge to learners’ everyday life, the source of mathematical knowledge was ruled out of their creation.

Further, the content and concepts were largely theoretical and dwelt more on hypothetical situations. The standard of accuracy in its procedures and operations was unique and unfamiliar to the learners who were used to working in general frames rather than exact terms or figures. The mathematical knowledge as experienced in school was such that it was what teachers taught and was found in text books, while in out-of-school context the similar mathematical knowledge was in discursive practices of the people and was embedded in activities. The learners, however, were not consciously aware of this knowledge and how they learnt it, though they were able to use it.

The content (subject matter) in school determined how the task would be performed; its logic dictated how the task would be performed. The school and its mathematics practices introduced different registers with its symbolism. For example the following registers were in different representations

\[ \begin{align*}
0.20 + 0.25 & = \frac{1}{5} + \frac{1}{4}, \\
\end{align*} \]

and the verbal form was yet another form. The learners came from a background of oral tradition, with most of the knowledge held was ‘in activities’ and discursive practices of their community.

The epistemological basis of mathematical knowledge as dealt with in school was such that a mathematical knowledge or concept could be understood from its formal definition or from its theoretical use (see chapter 5 sections 5.3.1, 5.3.2). It did not depend on empirical, or physical existence of the objects. According to Bernstein, this knowledge belonged to what he referred to as vertical discourse; it consisted of specialised symbolic structures of explicit knowledge, where its procedures were linked to other procedures hierarchically.

Thus, there were epistemological differences between the everyday practices and the school practices of the mathematical knowledge. The epistemic practices from the social organisation of the learning to the nature of the mathematics knowledge itself showed there were some differences. Learners had to resolve, negotiate their way over the challenges that these practices entailed upon them. Learners experienced conflict and
in some cases tensions as they interacted with the school practices. Section 6.4 below looks at the learners’ reaction/behaviour in the school context.

6.4: Interface between out-of-school and in-school mathematics epistemic practices.

The interface between the two knowledge practices took place albeit tacitly in the sense that the teachers and the pedagogy adopted worked to avoid this. This was exemplified when teacher(s) of the first graders taught or began their mission by introducing school practices by discouraging learners from exhibiting their ‘local practices’. Thus, learner’s background understanding, their expectation and their mutual interpretations were hidden. The learners’ behaviour or conduct could be seen in body language and in response to the interviews with the researcher. When learners were asked about how they tackled a given task, they fidgeted or withdrew from the conversation with the researcher or teacher (see chapter 5 section 5.4.1 and 5.5.1).

Amidst the suppressed/controlled environment learners’ everyday orientation was still their lens or way of looking at things. The nature of the common mathematical knowledge as held and practised from their community still informed their meaning making processes. Learners themselves were unaware of this knowledge as most of it was taken-for-granted knowledge operating at subconscious level. The learners’ reaction to the challenge of the new understanding of common mathematical knowledge in the school setting was shown through various behaviours. For contextualised tasks that learners understood, they were able to do these and they used their informal ways to solve the tasks. When the same learners were given a similar task outside the classroom, they attempted it without hesitation. Their ways took time, but many got the tasks right.

For example, when learners were given tasks in ratio and proportion in context. They were able to find solutions, as long as the problem was explained and they understood it. They managed to work out the problem using their everyday solutions. In the given tasks (see chapter 5 figure 5.4.1) question parts (a) and (b) were less complex, and learners reduced them to an empirical phenomenon and resolved them accordingly. For example, in task 2 part (a) (see same figure 5.4.1) “When Tiyeye drew 9 litres of water, how many litres of water did Mateyu draw?” (Tiyeye had a 3 litre bucket while Mateyu had a 5 litre bucket – they made the same number of trips). The task and the numerals involved could be matched or reduced to empirical phenomena. Learners were
able to match or place 3 litres or visualize Tiyezye making three (3) trips and there-by
drawing 9 litres of water. They did the same for Mateyu, there were three trips, which
meant, Mateyu drew 5 litres on the first trip, 10 litres on the second trip and had 15 litres
by the third trip. Learners were unsure about whether what they knew in the community
could be applicable in the school mathematics practice. The learners brought in their
own knowledge into the school setting. They used their ways as they had grasped what
the questions required of them. Thus, in this case learners utilised their ways from the
community to resolve the problems and only presented the final answers for checking.

Learners were able to handle tasks whose epistemological basis was consistent
with their background knowledge (orientation). Thus, in situations where learners
utilised both knowledge forms in the tasks, that is, where they ‘code-switched’ between
their everyday or empirical based approaches and the school (decontextualised)
approaches, learners understood the task and they resolve it. That is, where some aspects
of the task could be related directly to concrete forms, learners fell on these, switching
between everyday ways and the taught algorithms.

The ‘code-switching’ between empirical phenomena and the school mathematics
was for situations or cases where learners could harmonise the epistemological bases of
the two areas. Most of the common mathematical knowledge as projected in school
mathematics’ epistemological perspective was context-‘free’ (utilised mathematical
objects rather than grounding into concrete forms) and relied mostly on written
symbolism. As taught/presented by the teacher(s), it was abstract and very formal,
largely operated on algorithmic procedures in ‘as-if’ non-real situations. The relations
between objects were depicted in formulae and could be manipulated without reference to
the earlier or initial statements. The mathematical signs or symbols ultimately always
relate to universal mathematical conceptual ideas not to concrete mathematical ‘objects’
(Steinbring, 2005). As Vygotsky explained, scientific concepts are due to theoretical
learning, that is, they are systematic and general and are initially empty (devoid) of
personal meaning. Thus, learning is based on learners’ appropriation of methods of
scientific analysis of objects or events in different subject domains (cited in Karpov,
2003). Thus the epistemology of the common mathematical knowledge as dealt with in
school mathematics was different from the community’s and learners got stuck when they
were given a task which they could comprehend, but had not been taught how to attempt it, especially where parts of the task demanded creation of theoretical (as-if) relations in the school mathematics way. The learners’ orientation was different and in such situations learners appeared not to have the ‘resources’ to tackle the questions. As exemplified in task 2 part (c) (see Chapter 5 figure 5.4.1) the problem was “On the last day a total of 64 litres of water was drawn. How many litres of water did Tiyezye alone draw? What about Mateyu? How many trips did they make to the well?” The task despite having a familiar ring to it posed a complex situation which could be resolved in either epistemological modes, except in the out-of-school mode, it required retracing the ‘steps’ to the empirical situation of Tiyezye and Mateyu making trips to the well. Then the learner would have to keep a record of both the number of trips, the litres of water drawn for each and between them, which would be a tedious exercise to do in order to resolve the problem. But depending on the numbers involved, it could be feasible or it could discourage any learner from attempting it.

In the school’s epistemological basis of common mathematical knowledge, however, the tasks required formulation of theoretical relations. The empirical phenomena could be pushed back or dropped altogether and instead learners could deal with the relations between the objects. The task in this case required dividing 64 in the ratio 3 to 5 (3 : 5). That is, using the school’s practice of common mathematical knowledge, first, 3 and 5 are added (3 + 5 = 8). The resulting sum is then divided into 64. That is, \( \frac{64}{8} = 8 \). Then for Tiyezye who had a 3-litre bucket, he drew \( 3 \times 8 = 24 \) litres of water, while Mateyu with a 5-litre bucket, drew \( 5 \times 8 = 40 \) litres of water. They made 8 trips on that day. From the manipulation of the numbers, the context is initially pushed back, and the sense of the problem is only ‘restored’ at the end. For many mathematics problems in school context, however, the sense was never ‘brought’ back as final figures usually remained.

6.4.2: Apparent common epistemological phase

When learners made sense of an object or event, they used their background knowledge to form a meaningful context for interpreting the object (Voigt, 1998). Thus, in cases where the mathematical knowledge had direct relations with empirical
phenomena, learners appropriated the concepts as the context and orientations of the
to knowledge was familiar. For example in the problem involving crops and farmers,
learners did not have difficulties with the concepts and these fitted their background
orientation. Similarly in the tasks that were given to the learners (see chapter 5, figure
5.4.1 parts (a) and (b), the learners reduced the tasks to known empirical phenomena thus
achieving a known frame in which they operated without difficulties. Diagrammatically
this could be represented as in figure 6.4.1

![Diagram](image)

- CEP stands for Common Epistemic Practices
- Everyday mathematics

Figure 6.4.1: Area of harmony between the epistemic

The other cases where it was perceived there was a common frame was when the
teacher brought everyday situations or metaphors or concrete materials to introduce a
mathematical concept. For example, when introducing ratios to the class, the teacher
used the following diagrams to illustrate idea of ratios,
In such situations where it appeared there was epistemological harmony, learners without teacher’s interference utilized their informal ways to resolve the tasks. In the case of learners in the grade six class, however, the teacher insisted on school mathematics procedures thus, the learners used both approaches, their local approaches verifying the school mathematics results. Vygotsky explained that spontaneous concepts play an important role in children’s learning as a foundation for the acquisition of scientific concepts. “Scientific concepts grow downward through spontaneous concepts, as spontaneous concepts grow upward through scientific concepts (Vygotsky, 1986). In order to understand new concepts and their mathematical symbols, learners needed to be able to decipher epistemological and social signs and this required construction of a relationship between knowledge that was already known and the new concept (Steinbring, 1998). As also Lakoff and Nunez, (2000) explained that for one to understand a mathematical symbol one had to associate it with a concept, something meaningful in human cognition that should be ultimately grounded in experience and created via neural mechanisms. As Kozulin (1990) also explained, at any given developmental moment there is a proportion between scientific and spontaneous concepts. However, a special process is needed to bring the learner’s everyday representations with the more abstract mathematical representations.

6.4.3: Epistemological differences

The lessons as observed in the research class, introduced the common mathematical concepts without recourse to the learners’ background knowledge or understanding of the same. The concepts were introduced according to school’s mathematics epistemological basis, that is, the concepts were presented as a coherent, explicit and systematically principled structure. In this context, learners experienced difficulties. For example when the teacher introduced multiples of numbers, the entry into the concept was ‘pattern recognition’. The teacher ‘presented a pattern’ from which he drew examples and procedures for generating other multiples of numbers (see chapter 5, excerpt 5.3.4). The learners noticed a pattern and followed the ‘rule’ for generation of numbers for a given set of multiples.

The inadequacy of the concept so developed was exemplified when learners were interviewed about the same. One learner said that 8 and other big numbers should not be
used in generating multiples. '7' was thought to be the last (largest) number. (All the examples and the exercises given requested the listing of multiples, from one up to 7, and did not go further. The learners, thus, thought that was how far the multiples went.

This situation could be depicted as in the diagram below:

![Diagram](image)

**Figure 6.4.2: Area where there is no or less harmony between the practices**

Although the diagram gives the impression that there is nothing common in terms of epistemic practices between some aspects of the school mathematics understanding of mathematical knowledge and the everyday understandings, overlaps are possible. That is, some aspects could be linked to empirical referents, for example, when learners were working out multiples of numbers, while the concept of 'multiples' itself did not have empirical referents in the community, the procedure for generating the set of multiples of a given number utilized multiplication operation which learners identified as 'repeated addition', which in turn they could relate to empirical referents.
Though learners' orientation for meaning-making was influenced by their cognitive tools for learning developed in their culture they could grasp some concepts in this epistemological mode depending on how the concepts were presented. As according to Lakoff (1987),

"In domains where there is no clearly discernible pre-conceptual structure to our experience, we import such structure via metaphor. Metaphor provides us with a means for comprehending domains of experience that do not have a pre-conceptual structure of their own. A great many of our domains of experience are like this. Comprehending experience via metaphor is one of the great imaginative triumphs of the human mind. Much of rational thought involves the use of metaphoric models."

(p. 303)

Thus in the new practice learners maintained the practices that shaped their thinking while at the same time tried to re-orient to the new practices demands. The results nonetheless showed that learners held the cognitive tools developed in the two practices separately, that is, not necessarily reconciling them. As Vygotsky stated everyday and scientific concepts (mathematical concepts) appropriation was fundamentally different types of learning. While everyday concepts were a result of empirical learning, school mathematics concepts were due to theoretical learning. However, the pure procedural knowledge displayed by the teacher, tends to remain meaningless and non-transferable (see Bruer, 1993, Davydov, 1990, Karpov, 2003 etc). Theoretical learning just as empirical learning nonetheless, also aims at selecting the essential characteristics of objects or events of a class and then presenting these characteristics differently, that is, in the form of symbolic and graphic models. And learners on their part are expected to increase these methods, as they form or serve as cognitive tools that mediate the learners' further problem-solving.

6.5: The nature and extent of the interface.

Learners came to school with a theory of knowledge, which was integrated in practice, that is, held in activities. The nature of their knowledge was practical, relevant to their lives and was designed towards a tangible or immediate goal. This was directly linked to the kinds of activities the people participated in or undertook in the community. Thus, the learners came to school with a particular orientation –background ways of
looking at knowledge. The epistemological basis of their knowledge was (directly) related to empirical phenomena. For example, the number concepts were related to materials, physical or and body parts. Learners' (everyday) ways of handling number concepts involved physical realities or direct one-to-one representations of these. In contrast mathematical knowledge in school mathematics was encountered as knowledge that had its own internal 'truth' and logic. It was divorced from reality and it existed independent of human intuition. Its epistemological base was such that mathematical knowledge or concept could be understood from its formal definition or from its theoretical use. It did not have to depend on empirical or physical existence of the objects.

Nonetheless learners participated in the school mathematics practices when/where learners had full grasp of the task and had the resources to resolve it. The tension experienced in this situation was due to the teachers' expectations. The teacher expected the learners to use 'taught' school mathematics procedures. For example in the problem context of two girls trying to find the number of litres (see chapter 5 figure 5.4.1) of Tiyezye and Mateyu a task they understood, the learners' hesitated as they did not have a known way of solving the problem in the school mathematics methods. They thus, looked to the teacher/researcher in this case for help or guidance. The classroom culture was such that they were 'guided' and given examples (procedures) to be followed for any type of problems. Thus, despite assurances and encouragement to learners to approach the tasks/problems using whatever methods/ways they felt comfortable with, they were still hesitant.

The learners proceeded to attempt the task using their informal ways, but were careful not to write or show these methods in their exercise books, instead they wrote on pieces of paper. When they found the answer, they asked for confirmation from the researcher. Meanwhile when learners were given similar problems outside the classroom/school setting they did not show any signs of hesitation. For example, when the problem on sets was given to four (4) learners, they all responded correctly to all questions. Learners performed well when they could harmonise the epistemological bases of the two contexts. Within this common framework a number of aspects were observed. There was deeper level of intersubjectivity in the activity in the sense that the
learners and teachers established a common frame of understanding and learners were able to bring into the interaction with the teacher, the ideas and the materials (objects) of their knowledge. They were a 'community of learners' as referred to by Rogoff (2003) at that juncture. There was a common focus of learning in context of communicating and accomplishing common goals.

The establishment of common basis or harmonisation occurred when the school’s understanding was brought in line with the learners’ perspective of the same concepts. That is, where the empirical phenomena and the 'mathematical objects' were in one-to-one correspondence and the concepts under consideration dealt directly with concrete objects. Thus, it did not matter, at this point, in which epistemological frame one was working in. Pedagogically, however this offered a key area or base for expansion and development. An example of such a scenario was from the grade one (see chapter 5 section 5.2.1, lesson on counting and addition of numbers). When learners were asked to add $7 + 8 =$, they were advised to use the sticks that each one of them had to assist in the addition 'algorithm'. That is, learners counted 7 sticks, put them aside and then counted another 8 and put them aside. Then the learners counted the two heaps together to obtain the final answer (addition of 7 and 8). The sticks (physical objects) that learners worked with tallied in one-to-one correspondence with the mathematical objects. Thus, learners did not have problems with such tasks. Similarly, in grade six, the learners did not have problems with the first two parts of the tasks which were quite contextual for the children. For example (see chapter 5 figure 5.4.1 for more details) task 1 asks for the number of jumps for Nthongase when Mbonyiwe jumped 4 times. Learners recollected or reduced the scenario to a situation they could identify with, thus, worked on an empirical phenomenon. Their solutions highlighted their use of concrete experience.

Hence learners largely used their local understanding of the mathematical knowledge. The solution process shows that the learners operated in a phase that was largely connected to their experience (concrete or experience in general). The understanding or practice of mathematical knowledge in school, however, for the most part dwelt or was performed in abstract form, that is, it was not directly related to concrete objects, but instead utilised 'mathematics objects' or was based on action(s) or
interrelated actions or relations. In the given case study, the actions of Mbonyiwe had a
direct relationship with Nthongase’s actions.

The challenge remained on how teachers were to expand the common
mathematical knowledge area where there was harmony of the understandings of the two
epistemological bases – see figure 6.4.1 above.

And also how learners could be assisted to cope with norm driven de­
contextualised mathematics discourse. At the outset the use of concrete materials and
everyday experiences appeared apparent/plausible, but it sometimes brought in confusion
or hampered understanding. That is, the empirical phenomena got on the way of
appropriating the concept. For example while introducing ratios, it was a remarkable
idea to bring in concrete shapes such as

\[
\begin{align*}
\begin{array}{ccc}
\square & \square & \square \\
\square & \square & \square \\
\end{array}
\end{align*}
\rightarrow 4 \text{ to } 6
\]

Many learners were just able to indicate the ratio of 4 : 6 as this tallied directly
with the concrete shapes. However, learners did not pay attention to the relationship
between the numbers (numerals). As a result when learners were asked to put or express
the ratio in its lowest terms, many learners failed to proceed with the task. Basically, the
concept of ratio and its related prepositional reasoning concepts i.e. as an arrangement of
objects according to set proportion was not grasped by the learners. See chapter 5 section
5.5.1 and 5.6.2) 2 : 5 gave the impression that learners understood the concept. Learners
focused on the direct relationship between the empirical phenomena and the numerals,
but they did not pay attention to the relations between the numerals, though that was
where the idea of ratio lay. The learners did not comprehend that 2 : 3 still represented
the ratio of the concrete materials of 4 : 6 (see chapter 5 section 5.5.1). The numerals
were not directly tallying with the concrete materials, thus it was causing difficulties.
The relation between the numerals was the same, a point learners failed to see. Meanwhile the teacher and the learners coordinated in their interaction and productively
engaged in the teaching and learning process on the assumption that they had a similar
understanding of the concept ‘ratio’. The learners, on their part, focused on the empirical
visual features, while the teacher desired them to see the abstract 'relations' between the concrete objects.

Most of the lessons on pattern recognition, definition, rules and practice and some identifiable content observed tried to build on the common mathematical knowledge. The concepts in this realm had their own logic and had an epistemological base (rationality) which did not necessarily depend on empirical phenomena. This caused difficulties with the learners' background knowledge and understanding. Learners lens or ways of knowing suddenly did not appear to make sense of this discursive practice. Learners' transformation in their ongoing participation in school practice was flout with difficulties, as intersubjectivity could not be easily established. The studies reviewed observed that pure procedural knowledge, whether learned in mathematics or in any other subject domain, tended to remain meaningless and non-transferable (e.g. Davydov, 1990, Karpov, 2003 etc). What was needed was for the learner to develop was the ability for highest generalisation (concept), that is, to be develop in the learner a system of psychological operations that were relevant and necessary for developing this highest generalisation (Karpov, 2003).

The poor performance in mathematics, to a large extent arose out of teachers not taking care of the step or rupture in the epistemological bases of the learners from their community of practice into school practice. The conflict was apparent when the learners were given tasks in context (see chapter 5 figure 5.4.1 for full set of tasks), some learners were at a loss as to how to proceed, while a few got round the hurdle. From the tasks given, many learners got stuck on the third type of questions, which were:

Task 1 part (c): "The total number of jumps of Mboyiwe and Nthongase were 30. How many jumps did each one of them make?

Task 2 part (c): "On the last day a total of 64 litres of water was drawn. How many litres did Tiyezye alone draw? -What about Mateyo? How many trips did they make to the well?

Task 3 part (c): "The third time around the government brought 24 bags. How many did each village receive or get?

These types of problems required the learners to first establish a theoretical relationship between quantities. It required learners to work within the school
mathematics framework or base. The group of learners that got stuck was due to the poor development of theoretical concepts. It required a theoretical relationship in 'formulae' form. Despite the context being clear, learners did not know how to address/deal with such tasks. There was a dissonance between the learners' orientation and the school mathematics' mode.

If the tasks are attempted in the everyday informal way, the learners need assistance for reducing it to manipulable actions or objects. A small group of learners attempted to do that. The solutions were 'untidy', messy, laborious, but the learners kept the goal of the activity in view all the time. This was not an isolated case but this was how the learners responded to such type of tasks. For example, the majority of learners could not handle problems/tasks that required them to reduce given ratios to their lowest form. The difficulties were further highlighted as learners attempted tasks involving conversion of units in measurements. The difficulty appeared to arise out of change of epistemological basis and non-attainment of theoretical concepts. The idea of creating relationship in formulae, relations between two abstract concepts from the point of view of learning brought about the conflict. The measurements in terms of 'cm', 'metres' did not have empirical referents. Moreover, in everyday use of measures such as body parts or other artefacts, the relationships between the measures was not abstracted and theorised to form general principles, rules or abstracted relations and therefore, was the source of confusion. In everyday life, learners were used to informal measures, which had direct relations with empirical phenomena and were utilised in a particular task. The learners' knowledge was structured around practical experiences and loosely defined everyday concepts. The students lacked any critical experience in the school that would have helped them develop theoretical concepts.

In the grade six teaching was based on theoretical arguments related to mathematical objects rather than empirical evidence alone (concrete materials or experiential world). The teacher wanted to impart this aspect of mathematical knowledge, which is characteristic of school knowledge. However, the adopted approaches remained syllabus and textbook centric. It was difficult for learners to transform or engage smoothly as their background epistemic practices interfered in learning the scientific concepts. It is important for teachers to help learners to extend or
broaden their understanding to encompass this aspect of mathematical knowledge by engaging them in multiple innovative activities. As Vygotsky observed, appropriation of mathematical (scientific) concepts cannot occur automatically, a teaching process that builds connection between the everyday and the scientific (mathematical) concepts is needed (Renshaw, 1992). As Davydov also observed, children do not pay attention to relations, as they lack a base for inductive generalisation. Thus, he and his colleagues designed a series of activities oriented to give children opportunities to cultivate, in a natural way, simple forms of reasoning that involved the relations of equality and order (Davydov, 1975 cited in Renshaw, 1992).

For teaching epistemological analysis of the objects of knowledge the teachers needed to moderate the meanings emanating from the group. In the present study the teachers were unaware of their vis-à-vis children's adopted epistemological frame. The first grade teacher positioned himself in the everyday ways of knowing framework. The concept of numbers was taught or introduced using the 'value' idea which worked well with the learners. While the sixth grade teacher worked largely in a different epistemological frame, the school mathematics' frame of discourse. The learners, however, appeared to operate in both systems, that is, at the intersection of the two perspectives. As Cobb et al also highlighted the mathematical signs and codes themselves do not have meaning, but for them to have meaning they require appropriate 'reference contexts' for learners to actively construct the mathematical symbols and meaning. Thus, within this zone of proximal development what lacked was the instructional dialogue that could endeavour to help learners move progressively toward greater abstraction and generality.

The epistemology of this contact zone of mathematical knowledge has not been sufficiently examined to be of help to teachers and educationists. Nonetheless, in light of what takes place, the following looks at the epistemic practices that resulted from the interface.

6.6: Common Meeting Ground of two epistemic practice(s) in Zambian schools

At the beginning of school (grade one), it appeared there were no major epistemic differences or changes as the source and the nature of knowledge remained closely related in the two settings. Only the teaching and learning method marked a significant
shift as compared to one outlined in chapter 4 for everyday knowledge. The teacher(s) especially in the grade six remained confined to the traditional pedagogic practice, long established discourse of school mathematics. That is, the teaching approach remained conventional and teacher-centred. Many learners, on their part rarely understood the school mathematics discourse. As they participated in the school mathematics practices, they were guided by their cultural 'scripts', their way of doing things or constructing meaning. As Rogoff (2003) stated, whether the activity was an everyday chore or participation in a test or a laboratory experiment, learner’s performance depended in large part on the circumstances that were routine in their community and on the cultural practices they were used to. “What they do depends in important ways on the cultural meaning given to the events and the social and institutional supports provided in their communities for learning and carrying out specific roles in the activities” (Rogoff, 2003, p.6).

In order to learn school concepts learners needed to expand their repertoire of practice (Gutierrez & Rogoff, 2003). They needed to add on new tools, ones that were not based on empirical referents, but on mathematical objects. As Vygotsky explained school mathematics begin in the domain of conscious awareness and volition, and form a logical system in a discipline. There are generalisable, removed from material experience and exist within a hierarchical network of related concepts (Vygotsky, 1987). In order for a child to develop the highest generalisation, it is necessary to develop in him/her the system of psychological operations that are relevant to this highest generalisation (Leontiev, 1983, cited in Karpov, 2003).

The Zambian teachers seemed to emphasise teaching of methods of solving problems (methods of scientific analysis) and learners’ task is to master and internalise these methods as they practiced them. There were not many innovative activities that would have helped students move from empirical concepts and discourse to theoretical ones. Davydov (1975) proposed that as children perform or manipulate objects, they should be assisted to talk in mathematical ways about the visual representations of various quantitative relations. Thus, the everyday terms used by the learners to describe quantities needed to be elaborated and made more precise and general, so that the learners move progressively toward greater abstraction and generality. Sfard (1994) also
wrote that the teachers should aim at providing a student with an appropriate experience. She says that the student is more likely to be converted to a new mathematical practice by living in a new mathematical world than just by talking about it.

To echo Cole and Subbotsky's notion the learners did not per se replace their everyday epistemic practices with the school ones, but the two lived side by side, with learners calling upon whichever practice they found appropriate (Cole & Subbotsky, 1993). The strength of their understanding of common mathematical knowledge from their everyday knowledge was such that it could not fade away. Learners appeared to 'store it' away as they tried to make sense of the new practices in school setting. The new practices or interventions to an extent conflicted with their orientation or way of doing things. Brown and Renshaw talk about a situation where everyday practices are replaced by formal, precise school mathematics vocabulary operating within the system of signs and symbols with its own logic and set of meanings. In the present study, the children's discourse was still bounded by everyday empirical knowledge. There were instances of the other type of discourse called interweaving by Brown and Renshaw where learners populate the classroom talk (discourse) with their own purposes. Their everyday ideas are interwoven with the conventions of mathematics. This is where learners use some of their methods along side those of school mathematics.

Thus, though the learners' cultural scripts or understanding appeared less visible in the practices of common mathematical knowledge in school, some aspect of it contributed to their transformation and to the practice itself. The aspect of 'code-switching' by learners provided a clue to learners' understanding of the objects in the school mathematics context (as in the case of Brown and Renshaw's interweaving). As the study showed when learners were given a task(s) in a familiar setting that required a solution in either of the settings, the learners used their everyday cognitive tools to resolve the task(s) as they were comfortable with these. In such situations as stated earlier learners were able to cope with the epistemological basis of school mathematics. And thus most of the learners attempted the task(s) using the cognitive tools as engaged in their community rather than school mathematics practice. This was despite the problems/task(s) being given to the learners in the school context (in the classroom).
However, learners’ successful transformation in their ongoing participation in the school mathematics practices in cases where the epistemological bases were different depended on the expert services of significant others (teachers). In this case the teacher(s) needed to find ways of bridging the gap or laying bridges for learners to cross from their epistemological perspective to the school mathematics practice one. In the observed lessons (see chapter 5, section 5.3.1), the learners did not have prior understanding/knowledge of or goals of the school mathematics sums as presented by the teacher. This suggested that the learners’ transformation through their ongoing participation in the common mathematical knowledge in school was new and received little support from the learners’ cultural ‘scripts’. Thus, interactions depended on the teacher’s guidance and explanations which allowed learners to participate in activities that would have been impossible for them alone.

6.7: Summary and Conclusion:

What is evident in the foregone discussions is that the school mathematics discourse in Zambian schools is a re-contextualised discourse that has elements of both in-school and out-of-school mathematics discourses (Panda and Ndhlovu, 2008). It is closer to everyday mathematics discourse in earlier classes, where as in higher classes, a mix of the both everyday and academic mathematics discourse was found. The case studies from grade VI reveal that children still struggle with theoretical concepts. They could appreciate it when they were made to operate within a familiar template (Panda and Ndhlovu, 2008). When the templates are not familiar, the learners were in loss. The teachers in grade six emphasised the semiotic system of academic mathematics though learners’ access to this system was not adequate.

The concepts such as ratios, factors etc. had its’ own internal logic and truth. It could ‘stand’ alone without reference to local context. The mathematical concepts (content) could be understood from its formal definition or from its theoretical use. Thus, its epistemological basis hinged on relations between objects rather than between numerals and empirical phenomena. The children both in grade one and six depended heavily on their everyday experiences to make sense of the mathematical reality and the concepts. In grade I, the teachers themselves brought in lot of everyday examples, materials and ideas to teach the young children number concept, place value etc.
Whereas, the teachers in Grade VI though allowed some everyday experiences and activities to inform the classroom teaching, they emphasised the routines, templates and the procedures for learning and production of classroom knowledge. The children were often found to have hidden the informal ways they used in the class. Most children excepting few had not developed any theoretical understanding well. So, they faced problems when they were asked to strictly operate within the logic of school mathematics discourse. They could, sometimes, solve the problems because, the teacher presented the problem in familiar template, as was found in the case of teaching of factors. The teachers, though, tried in their own ways to link everyday ways of knowing and doing mathematics to the school mathematics concepts and method, they failed to exhibit any understanding of how to help children shift from everyday discourse to school or scientific discourse. They emphasised specific use of mathematical signs, symbols and registers, standards of accuracy, language etc. without working sufficiently on how to help children develop the representation system and learn to use a specific semiotic medium for thinking.

There were major epistemic differences in the learning paradigms. In the community (everyday), learning was informal with no particular order of learning, use of formal methods or agenda in place. The standard of precision or accuracy was loose. The learners were immersed in their cultural activities and participated as and when they were ready, with adults and peers providing support. Hierarchy was held high. The elders and adults and seniors were respected and it was believed that they hold the knowledge and the responsibility of ensuring continuity of the cultural norms.

In school, one clear extension of community values was found in the area of authority, hierarchy and discipline. The authority and knowledge lied in teachers and textbooks. Learning was, therefore, formal and was centred around the teacher and the textbook. It was schedule driven and what was to be learnt was packaged in topics. It encouraged, precision, accuracy, particular routines and manipulation of mathematical ‘objects’ without reference to real world situations or experiences. The school mathematics practices involved learning in highly structured, restricted and time-tabled environments. Apart from teaching staff, learners too were part of the network of authority as class monitors or prefects. The teaching and learning in the classroom was
characterised by the teacher acting as a provider using the chalkboard extensively for teaching. The teacher led the conversations in class. The learners on their part participated through answering questions posed by the teacher and writing exercises given. The teacher presented the concepts in suitable packages for learners to follow. The school knowledge had its own registers and symbolism which could be manipulated, it had its own standard of accuracy in procedures and operations. It was thus, largely theoretical and dwelt more on hypothetical situations.

In nutshell, the everyday and school mathematics discourse ran side-by-side. So, the recontextualised school mathematics discourse had elements of a traditional Tumbuka society and some elements of modern Euro centric mathematics discourse. There were clear differences in epistemic practices between the traditional western mathematics practices and the version of the same used by the local teachers. The differences, however, did not amount to a different epistemology in the Zambian school(s).

6.8: Implications of the study

Implications of the study are focused at three areas in the education system (a) teacher preparation level (b) curriculum at primary (basic) education level and (c) at classroom level.

6.8.1: Teacher preparation

At this level, teachers could be encouraged to link mathematics concepts to everyday situations so that the epistemological bases are narrowed if not 'removed' but there are problems in the sense that,

1) not all school mathematics concepts/relations had empirical referents in the community.

2) While it is a good idea to mathematise everyday situations, there is not one way of doing this. In short depending on who is mathematizing, there could be different perspectives that could arise from the same situation (or mathematical relationships). Thus, there is not a one-to-one correspondence between the empirical phenomena and the mathematical signs/objects. An empirical phenomenon could have several alternative mathematical interpretations (Voigt, 1998).
3) Evans (1998) illustrated the problems of transfer of mathematical knowledge from one context (from classroom to practical situations) to another. He found that differences in goals and values, social relations and regulation and especially language and signification and emotional association between discursive practices made transfer highly problematical.

Though many researchers/researches have advocated the approaches where the focus was essentially on the everyday experiences of learners and then gradually moving to school mathematics discourse (D'Ambrosio, 1984; Ernest, 1991; Harris, 1999; Joseph, 1997; Lave & Wenger, 1991; Nunez, 2006; Walkerdine, 1988 etc), a lot of ground work is needed at the teacher preparation level. Teacher preparation should include curriculum organised around cultural historical principles of learning, mediated by a range of discourse and embodied practices, fostering the development of semiotic toolkit for deep learning across subject matter domains, with particular affordances for students from non-dominant communities (Davydov, 1975). This should include ways of making visible the social practices in which learners participate as well as the tools that mediate their understandings. As the study has revealed there is need to examine the kinds of understanding and sense-making experiences that provide the initial grounding for the construction of shared communication. The teacher preparation curriculum should include these aspects among others.

The teachers should be equipped to teach methods of solving problems. Learners should be assisted to select the essential characteristic of objects or events of a certain class and then present these characteristics in the form of symbolic and graphic models. The teacher’s role should be to teach these methods of scientific analysis (problem solving) and the learners’ task should be master and internalise these methods as they practice using them. A repertoire of these will serve as cognitive tools that mediate the learners’ further problem solving.

The teacher’s pedagogic knowledge should also include ways of utilising ‘as if’ discourses in ways of establishing a recognisable common discourse frame between school and everyday mathematics knowledge (Panda et al, 2007; Panda, 2006). As they have indicated, when students carry out the discourse on the cultural activity or artefact based on the numerous ‘as if’ assumptions that underlie various aspects of this activity,
they attain a layer of intersubjectivity among themselves and also with the teacher. An ‘as if’ attitude not only helps one to take a particular view, but it enables the person to attain epistemic freedom from certain other empirically bound views (Panda et al, 2007). As this study focussed on epistemological practices in the two settings this offers one of the way forward in terms of addressing the different orientations (thought systems), between the everyday knowledge and the school mathematics practices. As noted in the study the Ngoni/Tumbuka mathematics practices had aspects that were peculiar to it. In order for them to appreciate the school mathematics system, they needed to ‘free’ themselves of this disposition/orientation. Teacher preparation in Zambia needs to reflect sufficiently on these aspects of child’s thought than only focussing on school mathematics.

6.8.2: Curriculum

The curriculum at primary (basic) education level should include a wide variety of problem situations that engage learners in knowledge generating activities, so that they learn key features of the process of knowledge generation (Davydov, 1975). Davydov’s curriculum showed evidence suggesting that learners learn a great deal about the epistemic practices of mathematics through such experiences. He proposed that as children perform or manipulate objects, they should be assisted to talk in mathematical ways about the visual representations of various quantitative relations. The terms that learners use in their everyday mathematics should be elaborated and made more precise and general. So, the curriculum makers in Zambia need to carefully review the existing mathematics curriculum and revise it wherever necessary. The team can refer to Davydov’s work for revision.

6.8.3 Classroom Pedagogy

Teachers should endeavour to investigate the mathematical ideas and practices of the cultural, ethnic, linguistic communities of their pupils and to look for ways to incorporate them into the classroom teaching. Their understanding of the socio-cultural environment of the learners could help them make children’s everyday experiences as the starting point for mathematical activities in the classroom.
Teachers’ should develop/establish a ‘community of learners’ and institutionalise the knowledge being constructed together with the learners. It should be shared knowledge, which is interesting, stimulating and involving activities that can reveal the underlying mathematical structures or processes and their potential generalisability (Bonotto, 2001).

As teachers adequately prepare to build on learners’ prior understandings and engaging learners in conversations about their everyday experiences, the use of metaphors might be another way of overcoming the hurdle of learners not having the pre-conceptual knowledge for the new concepts/knowledge in the school mathematics practices. As Lakoff (1987) has indicated

“In domains where there is no clearly discernible pre-conceptual structure to our experiences, we import such structure via metaphor. Metaphor provides us with a means for comprehending domains of experience that do not have a pre-conceptual structure of their own. A great many our domains of experience are like this. Comprehending experience via metaphor is one of the great imaginative triumphs of the human mind; much of rational thought involves the use of metaphoric models.” (p. 303)

Thus mathematics teaching should bereshaped to include the everyday experiences of the learners, at least in school, where different culturally distinct social groups might not have equal access to its concepts, and to the wealth and power of its knowledge (mathematics) “... needs to be studied in contexts which are meaningful and relevant to its learners, including their languages, cultures and everyday lives, as well as their school based experiences “ (Ernest, 1991, p.xii)

For learners from communities not traditionally involved with school practices adaptation of both home and school practices was required. McNaughton (1995) referred to this as developing dexterity, in a collaborative approach optimising both community and school practices (cited in Rogoff, 2003, p. 358). And teachers are key to such a programme; teachers should try to understand local patterns of communication both in and out of school, as this may facilitate school involvement by people whose communities have not traditionally been involved in this institution. This could alleviate
the problem of disjunction between the communication styles of home and school (Rogoff, 2003).

Also there should be a system wide approach, which apart from focussing on the teachers, their teaching, and the curriculum, should focus on various institutions involved in the process. Other than focussing on the classroom or individuals (e.g. teachers), there could be a focus on institutional changes too. Cultural changes occur as people begin to work together so that collectively the problem can be confronted, drawing on the ruptures that learners face in their everyday practice in schools in mathematics classrooms (Lave & Wenger, 1991). The school may place less emphasis on hierarchy, draw on children’s knowledge, treat children as equal partners in the endeavour of learning together etc. this requires changes in the institutional values, orientations and organisation.

6.9: Limitations of the study and directions for future research

- The presence of the researcher in the classroom might have affected the ‘natural’ progression of the lessons. This could have affected the behaviour of the teacher and the learners. Although the researcher assured the teacher that the observations were not about judging him personally or even professionally and that whatever was observed was not going to be reported to his superiors (immediate or higher) still, some aspects of the lessons might have been affected.

- Observation of teachers’ and learners’ behaviour including gesturing, facial expressions in class would have been better captured by using video-recording facilities. That is, the analysis from the video-tapes could have complimented or in some instances provided more information on the behaviour and moods of the teacher and the learners. The video-recorder, however, was not available.

- It would have provided much richer data if learning activities such as building a house were observed in different contexts by different expert builders so that some aspects could be collaborated and a deeper analysis of the meaning making process in both mathematical knowledge and other community knowledge could be checked. However, this was not possible as building activities could not be determined before hand; one was chanced and observed.
• In order to collaborate/check concepts or information presented by the teacher or learners and their responses, one would have required some lessons to be repeated with same or different methodologies. However, this was not possible as the class was not necessarily an 'experimental class'. The lessons observed were part of the ongoing lessons in the class.

• Following up learners in school and in the community could have filled in the gaps so far mutual impact of in and out-of-school practices are concerned.

• The selected learners could not be interviewed immediately after the class. This was because they had to attend other classes. Negotiating time for the Group Discussions was problematic and in some instances it took place after a day and with only one or two learners present. Due to this, the learners could not recall some of the incidences in the classroom. Some valuable data could have been lost as a result of the delay.

6.10: Directions for future research

A lot of different aspects of the study could not be attended to either due to paucity of time or due to the specific objectives of the study. The future research can address these issues. The quality of interactions in the community could have been studied through a longitudinal study. The learners need to be followed up over a long period of time, before and after they enter school in order to examine how they form pre-mathematical concepts, how do they acquire mathematical ideas and notions in their everyday activities and what algorithms do they use when they solve everyday problems and how they engage in mathematics discourse when they come to school. The future research could look

Future work could also focus upon design, implementation and evaluation of teaching approaches that are realisable in the school context which aim to promote both conceptual and epistemological understanding amongst learners. That is, turning some classes into 'research classes' to facilitate the teacher or researcher to test or introduce interventions as appropriate.

This research project could be repeated utilising a video recorder to record the interactions in the classroom as well as in the community. Issues like how
intersubjectivities are formed, how learning takes place in the formal school system, why children fail in mathematics etc could be studied.

It was found in the study that although the local knowledge of the learners was suppressed, the development of 'new' mathematical concepts did not start from where local mathematical knowledge 'ended'. In fact learners moved back and forth along a 'bi-epistemological' continuum. The new mathematical knowledge was appropriated gradually as it was reconstituted for new functions (school use). A research on how this 'bi-epistemological' base is constituted and how it reaches back and forth to local and school epistemic practices as it functions in new situations needs to be investigated.