Teaching and learning of number concept in a Chinese primary classroom

Shasha Lan

Supervisor: Dr Azwihangwisi E. Muthivhi

Faculty of the Humanities

University of Cape Town

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by

Shasha Lan

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COMPULSORY DECLARATION

This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works, of other people has been attributed, and has been cited and referenced.

Signature: Signed by candidate   Date: 06 March 2017

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Abstract

The research investigated the practices of the teaching and learning of number concept and primary mathematics broadly, within a classroom context in China's Inner Mongolia province.

Informed by Vygotsky's cultural historical theoretical framework, and using an ethnographic approach—with triangulated data collection methods, the research examined a teacher's approaches to teaching primary mathematical concepts. The research explored the teacher's rationale and understanding underpinning her classroom practices in order to uncover sociocultural contingencies and influences on the part of both the teacher's and learners' framing of the teaching and learning of mathematics in a Chinese Grade 1 classroom.

The findings suggest that the teaching of mathematics, specifically number concept, has been and is undergoing changes, as policy regulations within the Chinese schooling system also undergo transformation. The findings further suggest that the introduction of learner-centred teaching into the Chinese curriculum policy framework has not significantly, if at all, supplanted teacher-controlled approaches in the classroom under investigation. While the emphasis placed by the teacher on precision and efficacy appears to have enabled learners to acquire the necessary skills and procedures to carry out the number operations, the concurrent lack of emphasis on individual, or authentic learner-centred approaches that engage learners in problem-based exploration of knowledge, appears to have inhibited the development amongst learners of independent and critical problem-solving skills.

Chapter 1

Introduction

1.1 Outline of The Research Topic

My research interest lies in the nature and characteristics of the classroom teaching and learning of mathematics in the Chinese cultural context. In this study, I discuss the instructional activities of a teacher, and how the cultural traditions around education in China are connected to and influence her teaching approaches in general, and her teaching of mathematical concepts specifically. I focus on the ways in which the procedures for teaching and learning number concept are mediated by the teacher in a Grade 1 mathematics classroom in the Inner Mongolia province of China.

It has been argued that mathematics education is one of the foundations of education across the curriculum, particularly in terms of understanding, acquiring, and applying concepts at primary education level. In addressing the challenges involved in the teaching and learning of mathematics, many studies have focussed on various aspects and perspectives of this problem, including the linguistic (Miller et al., 1995), and psychology perspectives (Rips et al., 2008). Each of these perspectives has both generated constructive suggestions for the teaching and learning of mathematics and, together with cross-national studies, has found culture to play a significant role in this. In this context, studies such as those done by Ginsberg and Song (1987), and Ho and Fuson (1998), have shown that different countries have different cultural and traditions, and that these significantly influence teaching and learning, that in different areas of the same country learners may learn differently, and that the cultural influences on teaching and learning may differ (Ginsberg & Song, 1987; Ho & Fuson, 1998).

Cross-national perspectives in research have generated a broad public interest amongst scholars in cross-national comparative studies which focus on the top performing countries in international mathematics tests. According to the findings of these studies, China often outperforms Western countries (Fuson, 2009; Norton & Zhang, 2013). Comparative studies on the teaching and learning of mathematics across different countries have been conducted in order uncover the reasons for this: how and why learners in different cultures, and/or at an individual level, learn differently (Wang & Lin, 2005).

However, these cross-national comparative studies have been limited to general comparisons between countries, and often simply to rates and statistics of performance, with little attention to teaching and learning at micro-level. Studies seeking specifically to uncover why Chinese learners show higher achievement have tended to give little attention to developing a refined exploration of performance differences in the specific context of classroom teaching and learning (Lin, 1981). These studies are often in the form of general surveys, lacking in-depth qualitative approaches to classroom activities with a microscopic focus. They also tend to omit crucial questions needing in-depth investigation: the specific ways in which teachers teach, and learners learn, with specific reference to the within Chinese cultural context. Thus limited insight, based on superficial comparative and quantitative data on the reasons for Chinese learners outperforming those from Western countries, has so far emerged (Silver, 2009). In order to fill this gap, my research explores at micro-level the ways in which a mathematics teacher teaches and her learners learn in a Chinese schooling context; in other words, how these culturally embedded teaching-learning activities help learners to acquire mathematical knowledge.

Number concept has been found to be an important cornerstone for developing mathematical knowledge and skills at primary level: it includes not only the essential basis for mathematics activities, but also the basis for constructing more complex numbers systems (Arievitch & Stetsenko, 2000). Moreover, scholars generally believe that learning number concept could develop high-level mathematical thinking (Miura et al., 1988; Zhang, 2005). Some scholars believe that the learning of number concept impacts directly on learners' problem-solving abilities, and on flexible thinking in a range of academic and social contexts (Miura, 1988). Thus the specific focus of this study is on instructional activities involving number concept.

In order to better understand how a Chinese teacher designs instructional activity to mediate number concept acquisition, this study uses Vygotsky's (1978, 1981) theory as a theoretical framework in order to describe, analyse and characterise the instructional activities observed in the classroom under study. Vygotsky's (1978, 1981) contribution to the theory of education was his exploration of the cultural impact on human development and how this shapes human thought (Wertsch & Tulviste, 1992). Vygotsky's (1978, 1981) theory helped me understand that learning number concept involves not only the acquiring of knowledge, but also the process involved in the transmission by teachers, and the internalising and application of this knowledge by learners, together with the ways in which mathematics teaching and learning can be seen as a cultural activity. Vygotsky's theory of how children learn is discussed in greater depth in the theoretical framework in Chapter 2. His theory provides a specific lens for this study: the specific ways in which individual development interacts with the socio-cultural context of teachers and learners. My hope in terms of the benefits of my research is that my study may enrich both Chinese education and instructional activities in general, and number concept teaching in particular. It may also potentially provide practical and theoretical guidance to education practitioners, in particular to those teachers teaching mathematics in contexts of minimal resources and support.

1.2 Rationale for The Research

My study focuses on how a teacher teaches, how learners learn, and how the teacher helped learners understand number concept, in one classroom in the Chinese socio-cultural context. Two important factors encouraged me to pursue this research project. First, the study combines two of my fields of interest: developmental psychology and education. My recently completed studying developmental psychology and education gave me a new perspective from which to view the process of teaching and learning: the transmission, acquisition, and application of new knowledge in a classroom context. In addition, having been through the Chinese schooling system, the study provided me with the possibility of an interaction of theoretical ideas with my specific educational experiences. Secondly, I have extensive experience teaching Mandarin both in China and South Africa, and both as a first and foreign language. Since my fieldwork was conducted in a Chinese schooling context, it involved observing and interacting within a schooling culture different from the one in which I taught in South Africa. This teaching experience has helped me to better understand not only the ways in which teaching-learning activities take place in different cultural contexts, but also the role that culture plays in learners' development of mathematical concepts.

I build on the idea put forward by Carpenter and Moser (1984), from their findings of a study done on mathematical concept acquisition in early primary school, that the area of number concept is of particular foundational importance in this process as it builds learners' central conceptual structure for developing their mathematical concepts, knowledge and skills. Studies done within a socio-cultural research framework show that cultural traditions of teaching and learning are significant elements in determining performance in mathematics, and in education in general (Seah & Wong, 2012). I have also looked at international mathematics studies, such as those by Fuson (2009) and Norton and Zhang (2013), which focus on cross-national perspectives in order to explore the relations between mathematics education and culture. As has been mentioned, these studies have found in recent decades that China often outperforms Western countries in international tests, such as the TIMSS (Mullis et al., 2012). The academic success shown in Chinese mathematics education has led many educationalists to explore the reasons for this (Wong, 2004). However, given that very few of these studies have focused on mathematics education at the classroom level, I considered that further research in mathematics teaching and learning practices should focus on instructional activities in the classroom context.

The limitations of many of the existing quantitative studies in this area have been mentioned in terms of their lack of in-depth qualitative observation and analyses of instructional activities in classroom contexts (Silver, 2009). Therefore, given the focus of the current study on the cultural traditions of instructional activities in China, and how these differ from those in other countries, I considered it crucial to investigate mathematics teaching and learning in the cultural context of Chinese schooling (Norton & Zhang, 2013).

1.3 Aim of The Study

The aim of this study is to explore the specific ways in which teaching-learning activities take place in a Grade 1 Chinese mathematics classroom, and to reflect on the cultural traditions influencing the mediation of knowledge and the teaching approaches, in other words, the ways in which the teacher mediates the learners' number concept acquisition, and how these provide insights into some Chinese instructional practices in a particular space and lesson's time frame. This involves identifying and analysing the specific cultural factors which influence the teacher's knowledge transmission, together with the ways in which the learners acquire and develop certain mathematical concepts.

1.4 Research Question

In order to achieve the research aim, the study investigates the instructional activities and approaches the Chinese teacher under study used and ensured that her learners would acquire number concept, and mediated her learners' acquisition of mathematical concepts associated with the concept of number broadly.

The main research question:

What is the nature of, and what factors influence, the instructional activities by means of which Chinese learners acquire number concept?

The following sub-questions arise from this overarching question:

- What does curriculum policy prescribe for learners to be able to master mathematical concepts at primary school level?
- What is the nature of instructional practices in mathematics teaching in a Grade 1 Chinese classroom and to what extent are these influenced by Chinese cultural traditions of schooling?

1.5 Dissertation Structure

In order to answer the research question, the structure of this dissertation follows a series of stages involved in the research process.

Chapter two presents a review and discussion of the relevant literature, including the theoretical framework. The main themes discussed in the first section of this literature review include those specific factors which influence learners' number concept learning, such as age, home language. The next section sets out the theoretical framework for this study, using Vygotsky's theory as a tool for the analysis of the interaction of teaching and learning within a cultural context.

Chapter three describes the research methodology and outlines the procedures used to analyse the data collected through observation of the processes of teaching and learning in the Chinese Grade 1 classroom under study. The study employs a qualitative research approach, using a case study of a classroom in a school in China, and an ethnographic method. Data collection tools included a questionnaire, interview, observations, and samples of learners' written work in the form of transcripts of homework and examinations. One week of mathematics lessons was observed in order to investigate closely the ways in which the teacher was teaching and the learners learning. Ethnographic methodology guided the data collection and interpretation.

Chapter four presents the analysis of the empirical data. This analysis identifies and categorises the teaching and learning strategies in which the teacher and the learners were involved and interacted. These data are analysed according to various categories of teaching and learning approaches in a Chinese context. Chapter five discusses these findings. I draw conclusions from my analysis.

Chapter 2

Literature Review and Theoretical Framework

2.1 Introduction

This chapter provides an overview of the empirical and theoretical literature in the area of mathematics teaching and learning utilized as a framework for this research. The review first provides an overview of the concept of zero and its foundational role in providing both a basis and a perspective for learners in their acquisition and development of mathematical concepts. The empirical focus of the review is on those studies which investigate and compare mathematics teaching and learning at pre and primary school levels in different cultural contexts. The focus moves to an exploration of literature contextualizing and developing the debate around the reasons for Chinese learners achieving higher scores in international tests relative to Western learners. The chapter concludes by focusing on a discussion of the international literature, especially those studies focussing on language, and its relationship to cognitive development. In the course of reviewing this comparative literature, I identify the gaps and limitations mentioned in the introduction (Chapter 1), in the findings of these studies in terms of their general comparisons between countries, and their lack of attention to in-depth exploration of teaching and learning in the context of the classroom.

The second part of this chapter reviews that literature which provides the theoretical framework for, and the key theoretical concepts underpinning, the study with a primary focus on Vygotsky's (1978) theory in terms of the socio-cultural perspective used to investigate classroom practice in a Chinese schooling context, and the ways in which this may ultimately influence learners' performance in local and international tests. Vygotsky's concept of the general genetic law of culture development is described, followed by an explanation of his concepts of mediation, internalisation, and the zone proximal development (ZPD). Vygotsky's (1978) theory encompasses and explains both the internal relations of mental development and the external cultural context of educational activity. This theoretical framework is used and developed in order to explore, identify and characterise the instructional activities mediated during engagement with teaching and learning in the case under study. These theories and concepts informed my classroom observations of this process, and assisted me in identifying, describing and categorising the specificity and frequency of a unique cultural tradition of Chinese schooling manifested in the mathematics teaching and learning practices taking place in the classroom under study.

2.2 Literature Review

Lin (1981), and Wellman and Miller (1986) found that the internalising of specific concepts and mathematical skills at an early stage in schooling influences and facilitates further learning in mathematics. These researchers found that learners experienced the learning of the concept of zero as being more difficult than learning other numbers, and that learners often mistakenly believe that a minimum number is one and not zero, as zero itself is an abstract concept and difficult to understand in terms of using an intuitive object to represent its meaning. Similar evidence was presented in Lin's (1981) study, which found that, in any process of internalising basic mathematical concepts zero is the most important number concept in terms of learners being able to build on this for further acquisition of mathematical concepts. Hence, zero is a mathematical concept which is the scale starting point or boundary for the acquisition of more complex mathematical concepts. Baroody and Ginsburg (1990) argued that understanding mathematical concepts is an iterative cognitive process: an understanding of previous numbers is a prerequisite and basis for learning subsequent numbers, while subsequent numbers will generally deepen and consolidate the understanding of previous numbers.

Mathematics education research in recent decades has focused mainly on primary school mathematics and, as has been mentioned, has been based on comparative studies whose purpose has been to explore ways of improving mathematics education by looking at the process of acquisition of mathematical concepts amongst children relative to their performance in standardised tests. In the 1980s Ginsberg and Song (1987), in their comparative study of US and South Korean primary school children, argued that, even when learners in two different countries achieve differently in mathematics. The study compared South Korean and American learners' formal and informal mathematical knowledge using 4 to 8-year-olds learners in kindergarten, and Grade 1 and Grade 2 learners. They found one significant difference between the two groups was that American learners' informal mathematical knowledge was better than that of South Korean learners, but at 7 to 8-year-olds South Korean learners performed at a higher level than did American learners in the same age group. The data was interpreted as showing that two different cultures may influence different achievements, even the order in which these groups of primary school children were acquiring mathematical skills was similar (Geary et al., 1996).

Miura et al. (1988) focused on pre-school learners in a cross-country comparative study between China, South Korea, the US, and Japan. Their study based on the studying of number representation and showed that, in all four countries, there was no significant difference in mathematical development between these groups of learners before they entered the formal education system, but that in China learners who received formal mathematics education at pre-school level performed significantly on number representation better than these who had not received formal education. The results of their study have been confirmed by subsequent international test results and by a range of researchers: China produces the top mathematics performance scores overall in the world (Ginsburg et al., 2005; Mullis et al., 2004; Silver, 2009; Wang & Lin, 2005). In fact, at the time of the study, China had even outperformed Japan, South Korea and other East Asian countries (Miura et al., 1994; Mullis et al., 2012).

Mathematics studies moved on to more qualitative studies whose purpose has been to explore the reasons why Chinese learners' performance in mathematics have been better than those of Western learners. Ho and Fuson (1998) combined a comparative study with specific concept learning. The study compared the comprehension and internalisation of the concepts of cardinal numbers among pre-school learners in China, to those in the US and the UK. The study showed that when 4-year-olds Chinese learners were able to fully understand concepts, they also showed an average or above average mathematical ability. They found that 5-year-olds UK and US learners still did not understand the concept inherent in the cardinal number, because they were basically using the counting method to understand numbers, even though they were able to complete most of the mathematics problems presented to them.

Although the studies conducted by Miura et al. (1988), and Ho and Fuson (1998), showed Chinese learners achieving higher scores in international tests than Western learners, the studies did not explore the reasons for this. This limitation led subsequent studies to focus on the possible ways in which Chinese learners learn mathematics differently to their Western counterparts, and what specific factors account for them performing better in international tests. In an important study, conducted prior to Ho and Fuson's (1998), Miller et al. (1995), contributed a specific linguistic perspective to the analysis of mathematics teaching and learning at primary school level. The central idea of their study was that the nature and semiology of a particular language influences learners' mathematical concept acquisition

(Miller et al., 1995), and that Mandarin significantly facilitates cognition development for learning counting (Miller & Stigler, 1987).

In order to investigate the ways in which Chinese learners' behaviour reflects on symbolic representation, Miller et al. (1995, 2005), together with various colleagues at various times, conducted a number of comparative, cognitive, and semiotic studies on children's acquisition of mathematical concepts at pre and primary school levels. Miller et al. (1995) initially compared groups of learners in Western and in Asian countries. Their study compared American, Japanese, and Korean learners' acquisition of cognitive representation of number. The studies of Miller and Stigler (1987), and Miller et al. (1995) found that Asian languages share a similar linguistic and semiotic structure to Mandarin, and that the Mandarin mathematics language facilitated the understanding of mathematical counting (Miller & Stigler, 1987).

Miller et al. (1995) argued that language influences learners' learning of mathematics, especially for those learners who experience difficulties with counting from one to ten as the base of learning number counting. In a linguistic and semiotic comparison of English and Chinese study, Miller et al. (1995) found the two number systems to be very different. English speaking learners' performance often generated incorrect number names in comparison to that of Chinese learners. According to Miller et al., in their later 2005 study, English does not have a direct relationship between the concept of order and that of number, and that Mandarin as a language facilitates counting based on a ten numeracy system better.

Miller et al. (2005) further argued that Mandarin as a language also influences learning consistency of number concept. Language influences not only the learning of the ten base number system, but also formal mathematics education in general, especially, the learning of cardinal numbers. For English-speaker, according to Miller et al. (2005), learning of ordinal numbers was delayed as a result of language. However, Mandarin-speaker only need to add the word "di" to represent the order, therefore, after Mandarin-speakers have learned the natural number, they are able to directly know the relationship between the ordinal number and cardinal number. Therefore, according to these studies, Mandarin word formation seemed to construct mathematical terms that are potentially clearer than those formed in the English language, resulting in potentially deeper understanding than is typical of the English language number counterpart (Miller et al., 2005; Miura et al., 1994).

Therefore, these studies on the relation of language and semiotic systems to the acquisition of mathematical concepts suggest that Mandarin facilitates Chinese learners' learning of mathematics more easily than English or European languages do. This would seem to reflect an apparent Mandarin linguistic and semiotic clarity in the transmission and representation of mathematical ideas (Han & Ginsburg, 2001). In this context Han and Ginsburg (2001) argued that Mandarin mathematical semiology seems to be conceptually clearer than that of the English language.

However, as has been mentioned, these studies have been limited to general comparisons between countries, and have not focused on exploring learning within the schooling context. Therefore, to understand the practical classroom activities through which the cultural-linguistic declivities of schooling are manifested, the present study draws on Vygotsky's (1978) socio-cultural framework to investigate the cultural-linguistic influence on instructional activities within a Chinese mathematics classroom.

2.3 Theoretical Framework

According to the Vygotsky (1978) concept of the general genetic law of cultural development, human mental functions together constitute a product of social history, a product restricted by cultural factors. The general genetic law of cultural development is based on three core concepts: mediation, internalisation, and the zone of proximal development (ZPD). I describe each concept in detail and discuss how this theory provides a theoretical framework for this study.

2.3.1 General genetic law of cultural development

Vygotsky (1978) distinguished between two kinds of human psychological functioning: the natural and direct lower level mental functions, and the social mediated and indirect higher mental functions. Human psychological development proceeds from lower mental functions to higher mental functions. Vygotsky (1981) saw human higher mental functioning happening on two planes: the inter-psychological plane and the intra-psychological plane. Miller (2011a) elaborated on Vygotsky's notion that the human development appears twice. Firstly, human development appears on the social category between people as an inter-psychological plane, and then appears on psychological category within the learner as an intra-psychological plane. This socio-cultural perspective is further explained in Vygotsky's (1978) much cited *general genetic law of cultural development*.

Vygotsky (1978) saw general genetic law as having three major themes: firstly, it is rooted in social relations and mediated by signs, which he refers to as mediation tools; secondly, these tools are not created in isolation but are products of the socio-cultural evolution of an actively involved individual; thirdly, learning is inextricably related to a developmental or genetic process. This concept emphasises the importance for both researchers and teachers to concentrate on the process by which higher mental functions are established.

Wertsch (1991) argued that the transit from social cooperative activities to individual activities moves from the outside of inter-psychological to internal intra-psychological mental process. This process constitutes the human general mechanisms of development. Therefore, the Vygotsky genetic law focuses on connections between people and the cultural context within which they interact and share experiences. Vygotsky (1978) also argued that humans are socio-cultural products, and that the process of human development gradually transforms lower mental functions to higher mental functions. In this context, Vygotsky (1978) posits two distinct processes. One is a natural process which results from biological evolution and in which lower mental functions occur, such as physical maturity. The other process involves cultural and historical development, such as the development of logical thinking. In this way human development is guided by social interaction in a cultural context (Karpov & Heywood, 1998; Muthivhi, 2012; Muthivhi & Broom, 2009).

This concept is not focused on the general social or cultural environment in which the individual lives, but on the important role that social and cultural factors play in learners' development (Thorne & Lantolf, 2006). In other words, it places emphasis on human development being the result of the interaction between the individual's internal cognition and the socio-cultural context in which s/he learns or acquires concepts. The process of concept acquisition is the process of learners' use of psychological tools to carry out classroom activities, and to adjust their cognitive ability.

Vygotsky (1978) elaborated on the substance of human development, which reveals the relationship between inner awareness and cultural activity. In other words, human development initially comprises the process from socialised interpersonal interaction, and its transformation into individualization psychology, to functioning in an schooling context. This development is therefore not towards socialisation, but towards the social functioning of the individual in a range of social and learning situations (Vygotsky, 1981). From this point of view, classroom teaching-learning activities within the Chinese schooling context would be viewed as embedded in the Chinese cultural context, which is in turn influenced by certain processes, specific teaching and learning traditions, and culturally shaped conceptualisations of mathematics number concept.

According to Vygotsky (1978), the basis of the educational process should be learners' personal activity, and all education should be geared to guide and adjust away from teacher dominated classroom practice and towards this kind of activity. From this point of view, teachers are organizers of this cultural activity, and are also regulators of the interaction(s) taking place within educational activity (Chaiklin, 2003). Cultural activity is a powerful lever of the educational process, and a teacher's function can be summarized in terms of the management of this lever (Vygotsky, 1981). More especially, a teacher's function is reflected in how s/he uses culture as part of an activity to transmit knowledge, and how s/he ensures that learners through their classroom activities internalise their concept development.

Vygotsky (1978) defined education as a purposeful and planned activity which is simultaneously communicative and systematic. In the course of my observations of classroom activities, I work on the assumption that these activities present instances of the implementation of the kind of education which facilitates learners' development. In this way and bear in mind Rogoff's 1998 and Vygotsky's idea of a learner not being isolated individual, but existing among others who make possible his/her acquisition of social and cultural knowledge, and skills. Different cultural groups may place different expectations, and value on learners' mathematical abilities, and have different perceptions of mathematics education (Miller et al., 2005; Norton & Zhang, 2013; Wang & Lin, 2005). Thus, it is possible to view Chinese instructional practices in the course of social interactions as embedded in the Chinese schooling tradition as well as in the cultural practices of that society.

2.3.2 Mediation

Vygotsky (1978) saw mediation as referring to the acquisition of the cognitive tools necessary for learners to solve problems, particularly in the acquisition of scientific concepts that describe the nature of phenomena. Thus mediational processes in classroom teaching and learning involve the social relations in which learning activities are mediated by certain tools; these processes and tools are themselves products of cultural traditions. Mediation is the key to constructing knowledge which mediates both the social and the individual, and connects internal psychology with the external cultural context. Language in particular is a product of historical development and, as a mediation tool, contains and conveys both knowledge and concepts in social and learning situations.

Vygotsky's theory specified two mediation tools in a learning situation: physical-tools, such as the blackboard, and psychological-tools, such as language (Karpov, 2003), and Vygotsky (1978) saw language as playing a primary role in mediation, as defining and facilitating the inter-psychological move to intra-psychological functions. Vygotsky (1978) argued that language as a mediation tool initially used for social purposes and as a means to influence others in their cognitive development, later becomes a means to influence the individual's cognitive development. In human evolutionary terms, it is precisely through the use of language that human adaptation has taken place; language includes and facilitates all human indirect experience, that is, social and cultural knowledge and experience.

Informed by this theory this study, in the course of a series of classroom observations, looks closely at the process of number concept acquisition, on the assumption that number concept includes a variety of mathematical concepts. According to Vygotsky (1978), concepts, in the first stage in their acquisition and internalisation process, play the role of psychological-tools used by learners to acquire and consolidate mathematical knowledge, and later become internalised as symbols which can be used to understand and solve mathematical problems. However, concept acquisition is a process in which the teacher uses a variety of tools to transform concepts to symbols during interactive activities: learners internalise these concepts by transforming them into the higher mental functions through their participation in joint activities with each other and with their teacher. The studies of Miller et al. (2005) validated this process. Learners' mediation of development happens when they enter school, and particularly when they begin to acquire scientific concepts.

In the context of scientific learning, Vygotsky (1978) specified two kinds of concepts: everyday concepts and scientific concepts. An everyday concept is based on everyday knowledge and is summed-up by specific things in a child's everyday world, while a scientific concept is derived from the concept system of continuous extension and abstraction. The main difference between an everyday concept and a scientific concept in terms of concept acquisition and internalisation is that the latter is a systematic abstraction, while the former is concrete and lacks, or does not require, systematic abstraction. However, Vygotsky (1981) saw concept acquisition as the essential issue in teaching and in children's development, and as taking place under the teacher's guidance. Thus, teachers assist their learners in mediating knowledge in such a way that learners can internalise the external scientific concepts into internal mental development. Thus, Vygotsky (1978) placed particular emphasis on the teacher's teaching strategies/mediation in facilitating learners' acquisition of scientific concepts and cognitive development in general.

Engeström (2001) and Daniels (2016) developed Vygotsky's (1978) concept of mediation, combining cognitive development, learning tools, and human activities into the analysis framework of social practice activity. This social practice activity theory emphasizes the role of social practice in an individual's development, and provides a lens through which I was able to analyse the various instructional activities taking place in the case study (see Figure 2.1).

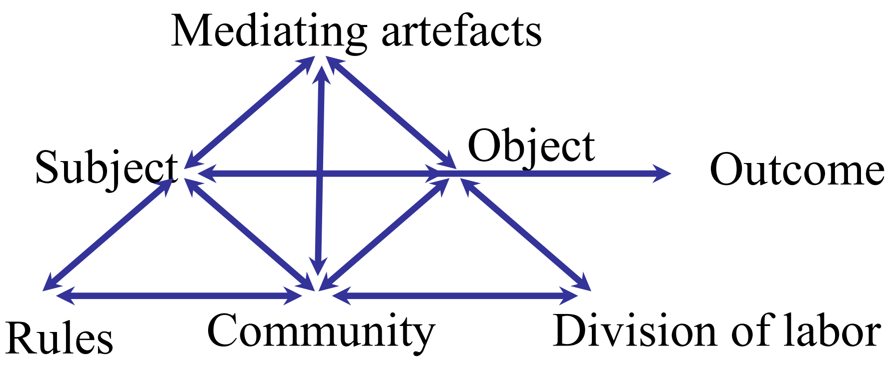

Figure 2.1. Social practice activity system. Adapted from "Expansive Learning at Work: Toward an Activity Theoretical Reconceptualization", by Y. Engeström, 2001, *Journal of education and work*, *14*(1), p. 135. Copyright 2016 by University of Cape Town.

In this activity system, it is the subject who participates in social activities, and individuals or groups (class of learners) seek to develop knowledge. The object is the goal of the activity, and is driven by the subject to engage in a series of activities, such as using certain tools to control the object. Community refers to the relationship between the activities and practice groups with common goals. Division of labour is the respective responsibilities and tasks of each member of the group. The rule is the system and the norm that the members of the group together abide by (Hardman, 2005).

According to Engeström (2001), both individual and cognitive development occur in an activity system which is constituted by these elements, and he showed how individual cognitive development and social practice activities are closely linked. In the current study, following Engeström's (2001) model, instructional activity is seen as a system, and, in the course of closely observing the instructional activities, the various elements in this system need to be carefully recorded, and analysed.

If, as Kozulin and Presseisen (1995) claimed, learners' mediation is formed when they enter school and acquire scientific concepts, and systematic school education is the main way to the formation of mediation, then the primary school teacher plays a crucial mediating role in this concept acquisition. The current study is based on the Vygotsky (1978) and Engeström's (2001) hypothesis that Chinese instructional activities constitute an interacting system between teachers and learners. The subject in the case study is the Grade 1 mathematics teacher, and the learners' classroom responses and their performance in mathematics constitute the object. The rules concern Chinese cultural practices and Chinese society's traditions of schooling. Division of labour would relate to the respective roles of teachers and learners. Mediating artefacts would be teaching tools, such as textbooks, and subject matter concepts. However, according to Kozulin and Presseisen (1995); the results of mediation should be the internalization of the relevant concepts and their associated epistemological procedures.

2.3.3 Internalisation

Vygotsky (1978) argued that, although external activities, such as those described above, mediate internal mental functions, and higher mental functions move the process from inter-psychological to intra-psychological, these processes may not yet be completed. Therefore, Vygotsky (1978) proposed a further concept: internalisation, which closely connects to higher level mental functions. Internalisation is an indispensable part of Vygotsky's (1978) theory, as, in the process of concept acquisition, external activities are transformed into internal activities (Veresov, 2010).

Therefore, on this basis of this transformation process, Vygotsky (1978) argued that higher mental functions are formed in the process of communication due to the influence of cultural contexts. According to this theory, higher level mental functions originally happen in the course of interaction between people. These interactions are expressed in the form of external activity and subsequently transformed into internal intellectual activity. In other words, the beginning of the development of higher mental functions involves society; internalisation realizes the external activity, and transforms it into higher mental functions. Vygotsky (1978) emphasised that higher mental functioning goes through an external phase in its development, and initially has a social function. Therefore, in the internalisation process, the overall developmental scheme begins with external social activity and ends with internal individual activity (Vera & Mahn, 1996). Therefore, in the process of internalisation, learners are not passive copiers of the cultural environment, but, on the basis of their original cognitive activities, actively construct and transform knowledge. Leont'ev (1978) builds on

Vygotsky's (1978) theory by arguing for the vital and foundational role played by education, which includes cultural activities, in an individual's internalisation process as well as in her/his personality formation. This developmental process is a product of the individual's ability to master and internalise the accumulated historical experience (and ability), and is in turn developed through education.

For purposes of the current study, instructional activity is seen as the culturalised process of teaching and learning, and thus important to closely consider socio-cultural context in the process of investigating how teaching mediate learners' learning, and how and why the teacher uses a variety of mediation tools to help students make the transition from everyday concepts to scientific concepts. Of specific interest to this study is the acquisition of number concept, a concept and process which comprises higher mental functions, and is an abstract and scientific form of knowledge. I work on the assumption that the number concept acquisition initially happens in external teaching-learning activity, and its internalisation can be understood as the process of cultural transmission, and transformation: internalisation plays a major role in achieving transformation from the external activity to internal activity, leading learners' development through teaching learners' in the ZPD.

2.3.4 The zone of proximal development

Vygotsky (1978), like Leont'ev (1978), saw school education as the source of human development, and that school learning creates, or facilitates, the zone of proximal development (ZPD) for learners, which in turn introduces a new developmental trajectory in the life of a child.

According to Vygotsky (1978), education should pay attention to the two levels: the first level is the learner's current psychological level, referring to a developmental level which the learner has completed and is now able to solve problems independently. In order to enter the second level a learner needs adults or peer assistance. In essence the ZPD is based on the idea that, before reaching the second level, learners cannot independently solve problems, but can do so at the next stage after having received assistance. Vygotsky (1978) emphasised that the ZPD reveals, or is tied to, the essential characteristics of instruction. These are not training and strengthening a learner's internal mental psychology, which already exists in a child, and has to some extent matured; ZPD is about stimulating internal mental functions which are in the process of being matured but are not yet fully matured (Chaiklin, 2003). Thus, the ZPD indicates and facilitates an on-going process of dynamic development which is subject to the usual limitations and constraints of cognitive development (Miller, 2011b), indicating clearly that teaching can inspire and spark learners' development (Davydov & Kerr, 1995).

According to this model, mathematics teaching is built on the basis of maturing development: it is between the matured level and maturing level, and only within these two levels, that instructional practices in mathematics teaching can mediate learners' learning. Conversely, if mathematics teaching is not aimed at, or does not take into consideration, the ZPD, then from a development perspective, this teaching activity has no positive significance in terms of learners acquiring mathematical concepts.

As has been mentioned, according to both Vygotsky (1978) and Leont'ev (1978), and to those researchers who built on their theories, such as Engeström (2001) and Daniels (2016), the principle of human development is influenced by cultural-historical development, and thus ZPD expresses the concept of cultural mediation, and creates learners' development. In proposing the idea that education should move ahead of development, Vygotsky (1978) argued that education per se is not development, but that appropriate and informed choice and organization of educational activities can lead to and is an essential factor in determining the development both of learners' social characteristics and their academic capabilities (Chaiklin, 2003; Muthivhi, 2010, 2012). Therefore, according to Vygotsky (1978), and subsequent socio-cultural theorists, the ZPD is important educationally in cultural contexts because teaching can be said to be a cultural activity whose aim should be to create, facilitate, and complete learners' cognitive development.

Vygotsky (1978) saw the ZPD as a concrete manifestation of cultural education, and as serving as a connection or bridge between education and cognitive development. In other words, teaching activity has the potential to create the ZPD and to promote a series of internal concept acquisition: mathematical concept acquisition is only realised in the activity between teachers and learners, and/or learners and learners, and these concepts are internalised to become learners' own higher mental functions (Karpov, 2003).

The concepts of mediation, internalisation, and the ZPD demonstrate that knowledge transformation happens in interpersonal activities, that teaching and learning are connected within and to the context of cultural-historical activities of schooling and society. Number concept acquisition is therefore constructed through this process of cultural activities by learners' themselves. The intrinsic connection between these three concepts therefore constitutes a complete system to investigate classroom instructional activities. It provides an analytical dimension to study mathematics teaching, based on classroom activities, together with subject matter concepts as tools that mediate and transform learners' knowledge, and development.

2.4 Conclusion

This chapter outlined the Vygotsky theoretical framework utilised to analyse the data collected for the current study. The research is based on the idea put forward by researchers in the 1980s such as Lin's 1981, and Wellman and Miller's 1986 studies that the concept of zero is more difficult to learn than other mathematical concepts, and that formal school education plays, or has the potential to play, an important role in the transformation and construction by learners of mathematical knowledge and that learners in different countries, while learning mathematical concepts according to the Vygotsky process, learn mathematics differently. Thus the literature review includes studies conducted by researchers from the 1980s up to more recent studies such as those of Norton and Zhang (2013), and including earlier studies done by researchers such as Ho and Fuson (1998) and Han and Ginsburg (2001), showing an historical progression in the development of ideas about the teaching-learning of mathematical concepts, and the effect of social and cultural context on this process. The current study also investigates the specific reasons for Mandarin speaking learners performing better in Mathematics than English speaking learners, and whether one of the reasons is that Mandarin, together with Chinese culture, itself facilitates mathematics learning.

Given that one of the foci of the current study is the specific reasons for Mandarin-speaking children performing better in mathematics than English-speaking children, and whether one of the reasons for this is that Mandarin, together with Chinese culture, itself facilitates mathematics learning, the findings of studies on the role of language and semiotics in the learners acquiring abstract concepts at school level were reviewed. In particular those which show the learning gap between different countries, and which in turn provide a perspective for understanding teaching and learning embedded in a cultural context were explored.

Vygotsky's (1978) genetic law of development provides an understanding of the link between extra cultural society, and inner psychology functions, and shows how, and the extent to which, cultural traditions influence both teaching and learning. The review also showed the importance in this context of Vygotsky's (1978) concept of the ZPD, mediation in particular. The conceptual system deriving from the theory provides a sound basis for investigating how the Chinese teacher under study mediated mathematical concepts, and provides a framework to explore the specific cultural activities that underpin a Chinese Grade 1 mathematics classroom.

Chapter 3
Research Methodology

3.1 Research Design

This chapter describes the qualitative research design used to investigate the teaching strategies used by the teacher for transmitting and/or facilitating the acquisition of mathematical concepts, and the ways in which her learners learned the mathematical concepts. The design takes into account the specific social and cultural context in which this teaching takes place. I chose to use a qualitative research methodology in order to be able to directly observe and explore, through the learners' learning experiences, how they, under the direction of the teacher, used a variety of methods and/or tools to achieve understanding, mastery, and application of mathematical concepts.

A qualitative research model in the form of an ethnographic case study design was used. According to Cohen et al. (2011), qualitative research uses a variety of data collection methods to holistically interpret social phenomena, and to provide inductive insights to formulate a theory. I considered that qualitative research could help me work through the research problems of this study, understand certain phenomena, analyse activities, and answer questions, in order to gain substantial and in-depth explanations of these phenomena.

The present study aims to investigate and describe in detail the character of instructional activities within a Chinese schooling context. In order to uncover the cultural activities embedded in these. I used several data collection tools: a questionnaire consisting of open-ended questions, classroom observations, an in-depth interview, and document analysis. At the same time, in order to insure the validity, authenticity, and credibility of the study, I needed to develop a broad understanding of the culturalised classroom practice. A Grade 1 classroom in China's province of Inner Mongolia was selected as the context, or setting, within which the investigation would take place.

Three advantages of qualitative research informed the design of the present study:

- Firstly, the function of qualitative research is to explore social phenomena or meaning and discover a whole cultural structure (Corbin & Strauss, 1990);
- Secondly, one of the main objectives of qualitative research is to explain and interpret, with the purpose of finding the truth, that is, to know and understand the concepts of what and how (Cohen et al., 2011);

- Thirdly, at the level of research method, qualitative research involves the actual operation of interviews, observations and grounded analysis (Strauss & Corbin, 2015).

Qualitative methods are not only important components of data collection; they also provide specific ways to analyse data (Cohen et al., 2011). This approach was used in conducting and interpreting the classroom observations, designing and administering a questionnaire, and structuring and recording interviews of the teacher. Investigating the ways in which the teacher taught mathematical concepts was a complex and delicate process which demanded a careful, sensitive and flexible interpretative approach, using the teacher's words and actions to infer and construct patterns of classroom practice. This process demanded a close rapport between researcher and participants within the particular situational field. This approach was fundamentally informed by the ethnographic approach and design.

3.1.1 Ethnographic research design

An ethnographic approach is used to understand a particular way of life through the experiences and perspectives of participants, with a view to understanding their culture, way of life, and everyday activities, and to reveal the significance of events and practices in socio-cultural contexts (Herche et al., 1996).

In this study, in order to identify the cultural patterns of classroom teaching and learning in a particular context, one needs to go beyond how the teacher treats and interprets her own practice, and uncover the underlying patterns of activities and the regulatory processes that potentially account for manifest expression, intention and behaviour. According to Cohen et al. (2011), ethnography concerns the group characteristics. It is able to show the real process of instructional practices, and reveal the cultural approach hidden behind events and practices, and its aim being to gather an interpretative explanation. Thus, in this study, although the object is a particular individual teacher and her classroom practices, the research approach considers whether or how, or to what extent, her instructional practices can be taken to be characteristic of the wider schooling context to which she belongs and within which she functions. In other words, whether the Chinese teacher and her learners' activities exemplified the practices of classroom teaching and learning of many or most Chinese teachers.

3.1.2 Case study design

A selected object comprising classroom instructional activities, or the teacher's practices through which the learning of primary mathematics and its associated concepts take place, was the focus of the case study used in this research (Yin, 1994). The following design principles described by Cohen et al., (2011), Sturman (1999), and Yin (1994) elucidate the design of the case study.

Firstly, case studies aim to describe phenomena as well as development processes through the collection and interpretation of data. Data for case studies are obtained through an exploration of a case; the case may comprise of an individual, an event, a group, organization, community, etc. (Cohen et al., 2011). Secondly, a case study design can be used to construct or examine a theory, as well as to explore, describe and explain certain phenomena. More specifically, when a researcher lacks understanding of a phenomenon, a case study approach can help in the exploration and in-depth interpretation of the phenomenon (Sturman, 1999). Moreover, in case studies, data collection is embedded in real scenarios, and as such, the authenticity of the site and sample can support the reliability and validity of the findings (Yin, 1994). More crucial for the design of the present study, a case study approach enables deep understanding of the internal structure and essential character of teaching-learning activities, as well as culturalised instructional activities (Merriam, 1998; Siggelkow, 2007).

Therefore, case study design enabled in-depth observations, and open-ended interviewing and questionnaire data gathering processes, in order for me to understand the culturally derived patterns of schooling and classroom teaching and learning of number concept. In line with the characteristics of a case study research design as outlined above by Cohen et al. (2011), This case study was specifically designed for researching a single phenomenon: a single classroom. It provided me with the opportunity to probe and interrogate issues in the kind of depth not always possible using other approaches.

The ethnographhic approach presented an appropriate 'fit' with the case study research design in that, as with the case study, is enables the interrogation of the meaning(s) underlying surface classroom practice; the approach can include the use of both the emic and the etic perspectives to interpret teaching and learning processes. As with the case study, it also allows the researcher to apply Vygotsky's (1978) developmental method that seeks to penetrate surface structures and reveal and/or recreate the underlying processes.

3.1.3 Sampling

This study uses purposive sampling. Cohen et al. (2011) saw purposive sampling as involving the selection of a case appropriate for enhancing the understanding of meaning, and this kind of sampling is based on the specific needs that the sample satisfies for the particular research purpose. In this study, within the purposive sampling, convenience sampling was used, as the researcher used familiar contacts and relationships in the process of selecting the specific school context that served as a research site. The object was not to make a general representation, but to pursue type representation. Through this sample, it was deemed possible to reveal the main elements of the processes, and to be as exhaustive as possible about specific events and relationships (Cohen et al., 2011). As a result, as Cohen et al. (2011) describe, a sample simultaneously becomes a theoretical and an abstract proposition, as the sample becomes a typical case.

The sample school was an upper-middle level, urban school located in Hohhot in the Inner Mongolia province in northern China. The school is a national compulsory experimental school with an average level of performance according to provincial scores but ranked within the top ten of regional schools. During the process of selecting the subject teacher, I first consulted the teacher who was considered by a seasoned teacher on the staff of the school to be outstanding in the school. However, this teacher recommended the teacher who ultimately agreed to participate in the study, which was limited to a one classroom case. This teacher holds a bachelor degree in education, an advanced level qualification, and she had fifteen-years working experience. There were thirty-five learners in her Grade 1 class who came from working and middle class family backgrounds, and were 6 to 7-year-olds. The five lessons which I observed were in the second semester.

3.2 Methods and Tools of Data Collection

Methods refers to the “range of approaches used in research to gather data which are to be used as a basis for interpretation, explanation, and prediction” (Cohen et al., 2011, p. 47), in other words, research methods are the procedures, techniques and tools used to gather relevant data. This study used triangulation which included a questionnaire, classroom observations, an interview, and document analysis. By interpreting information collected through this triangulation of methods, I verified as far as possible the findings across all data sources, and thereby sought to reduce the impact of potential biases which might compromise or distort the findings which may occur using a single method (Cohen et al., 2011; Mingers, 2001).

3.2.1 Questionnaire

Cohen et al. (2011) describe a questionnaire as a tool for collecting information in which involves the researcher compiling a set of questions and distributing the instrument to respondents. Therefore, in order to obtain certain in-depth knowledge and information, in addition to the interview, the researcher compiled a set of mainly open-ended questions for the teacher to complete. A questionnaire consisting of open-ended questions was chosen in this research for purposes of qualitative rather than for quantitative or statistical analysis, and for purposes of both eliciting in-depth information and understanding multiple perspectives.

The use of open-ended questions provides respondents with the opportunity to complete their responses using their own words and to "enable participants to write a free account in their own terms, to explain and qualify their responses" (Cohen et al., 2011, p. 321). Thus, the open-ended questions in the questionnaire helped the researcher to investigate and unearth complex cultural processes embedded in the teacher's classroom instruction, and to capture detailed information regarding her teaching and learning situation in a manner which closed-ended questions could not provide.

The questionnaire included six open-ended questions (see Appendix 1 for questionnaire), and was designed based on what I considered to be six key aspects of the teaching and learning situation relevant to addressing the research question. The procedure for administering the questionnaire was to be followed by classroom observations. I personally issued the questionnaire to the teacher, and explained the objectives of the study in detail, including the ethical considerations around her participation. I also provided any clarification she needed regarding the questions. The completed questionnaire was collected the following day.

3.2.2 Observation

According to Cohen et al. (2011), observation is a fundamental way for humans to understand and interpret the world, and is the most basic method for qualitative research. In this study, I used the scientific observation. According to Cohen et al. (2011) argued that scientific observation is a purposeful and planned activity in which the observer uses their senses or instruments to dynamically perceive and describe phenomenon as accurately as possible, and, through this process, obtain knowledge and information. Cohen et al. (2011), referring specifically to research in education, saw the classroom as the basic unit of school education, making it the most appropriate place for observation of teaching and learning. According to them, the classroom contains a wealth of valuable research elements through which classroom research has the potential to reveal the logic of the classroom practices. Classroom observation is therefore a practical and easy method for the observer to gather data directly from the classroom teaching-learning activities. In addition, observations enabled the researcher to understand and describe what really happened in teaching and learning and, through this process, to obtain knowledge and information additional to that obtained from the questionnaire and the interview.

In this study, I used classroom participant-observer observation to obtain data on the modalities of the instructional activities through which the teaching and learning of mathematical concepts took place. As a participant observer, I conducted the classroom observation for one week in order to observe the whole range of classroom practices. The observations were mainly—and somewhat loosely/flexibly—structured by the questions in the questionnaire and included questions aimed at understanding the nature of teaching activities, and capturing key instruction events. The data record of the observations was mainly based on field notes, with video recording as a supplementary tool.

A total of five lessons were observed, covering the topics recognition of numbers with 100; comparison of the double-digit; understanding the law of numbers; and two practice lessons. After each observation, I compared the answers the teacher had given in the questionnaire with the observation results to determine what information needed further investigation in the informal interview, and discussions for clarification. All these data provided the basis for the subsequent in-depth interview with the teacher.

3.2.3 Interview

Cohen et al. (2011) define an interview as a conversation and inquiry activity that uses verbal conversation to collect data. Interviews have greater flexibility than questionnaires, as well as space for interpreting meaning, and can directly elicit the respondents' views and opinions in their own language. In-depth interviews can help the researcher gain comprehensive information, revealing various aspects of the object. In addition, a face-to-face interview is an effective data gathering method as it allows for nonverbal information that includes the respondent's facial expressions and posture, etc. (Cohen et al., 2011).

Therefore, in this research, a semi-structured face-to-face interview was chosen as a method to collect data which would complement both the open-ended questionnaire and the classroom observations. According to Cohen et al. (2011), and Jantsch (1947), a semi-structured interview adopts a rough outline as the interview framework. It has an important advantage in its greater flexibility, and helps the researcher to extend, expand, and cover different aspects of the topic as these arise, or emerge, in the course of the interview. At the same time, the respondent's account remains the central focus of the data analysis, and the 'whole story' is the core of the interview.

The main interview questions were structured (see Appendix 2 for interview questions), but the follow-up questions were generated by the specific responses the teacher had given during the first interview. Based on the specific circumstances and context of the research, I adjusted the interview questions and made appropriate inquiries of the teacher for clarification and for her to elaborate on her responses in the questionnaire. In the course of the interview, I further confirmed her understanding of her ideas and views, and asked follow-up questions. The teacher permitted only two hour formal interview, which was scheduled once the classroom observations had been completed. All interview data was recorded on tape, and supplemented with field notes.

3.2.4 Document analysis

Bowen (2009) defined document analysis as a "systematic procedure for reviewing or evaluating documents, both printed and in electronic material" (p. 27). In other words, document analysis is a kind of bottom-up qualitative data collection method often used for refining conclusions from specific examples, as well as for hypothesis testing.

Bowen (2009) saw three advantages for document analysis. Firstly, it is easy to operationalise and saves time, and it allows for, and/or enhances, an in-depth case analysis. Secondly, it allows the researcher to correct possible mis-understandings or mis-interpretations of relationships within data through analysis and inferential reasoning based on objective information. Thirdly, it may be the most effective means of gathering and supplementing data when events can no longer be observed, or when informants have forgotten the details. Such analysis has the potential to provide both background information and historical insight. Therefore, document analysis is useful in research to supplement other data collection methods, particularly in verifying and making evidence consistent so as to reduce bias and establish credibility.

In the current research, the documents comprised of learners' test scripts marked by the teacher, as well as the textbooks. The analysis was used to gain a broad overview of learners' performance levels in terms of mathematical concepts, and to infer the patterns of engagement with the concepts. Despite the official process of informed consent and guaranteeing privacy and confidentiality for all participants including learners, there remained the unforeseen human factors that I encountered in class and had to contend with. In terms of assessment documents, some examination transcripts which had been issued to learners were not recovered, learners said they did not know where to write their answers, and some of these documents, such as homework, showed some wrong answers to have been modified by learners, and thus the original raw data was lost. Therefore, my record and analysis of data is restricted to those untampered documents I was able to analyse.

3.3 Methods of Data Analysis

Data collected during the study included one formal interview session of two hours duration, a total of four hours of observation, including five classroom observations, a questionnaire, and the classwork, homework and exam transcripts of thirty-five learners. The analysis used triangulation: the same problem was observed and interpreted using different analytical methods, or different channels, to collect the data and took into account both emic and etic perspectives in the presentation and interpretation of the analysis.

According to Harris (1976), Herche et al. (1996), Morris et al. (1999), and Zhu and Bargiela (2013), in ethnographic research, the emic and etic perspectives inform the specific ways in which the researcher interprets own experiences of the situation and the informants' local knowledge, as well as the researcher's theoretically informed interpretation of his or her experiences of the situation, informants' reports. This interpretive frame further guides subsequent analysis of data. Therefore, my emic perspective was crucial in terms of my personal knowledge and experience of Chinese cultural practices and China's schooling system, and as a Chinese researcher who grew up within, and participated in, the system. My etic perspective is informed by an understanding of Vygotsky's (1978) cultural-historical theory which I used in the detection and interpretation of the cultural practices embedded in the classroom practices, together with my knowledge and experience of Chinese schooling, including classroom teaching and learning.

In this research, the data analysis methods included looking for and identifying patterns in the classroom activities focussing on the instructional activities the teacher designed and used for learners to learn and acquire mathematical concepts. The data analysis followed the steps recommended by Cohen et al. (2011), which include organizing, describing, interpreting, analysing, and explaining the data collected, specifically in regard to key features relating to the cultural practices of classroom teaching and learning. The analysis began with taking a broad overview of the data and grouping all the raw data material in order to get a sense of the general themes. At the same time, field notes were reviewed, and all video records viewed, in order to get a sense of what data fitted to the research purpose, and which lessons I could particularly focus on to answer the research questions. The principle methods used to organize and present data were based on both fragmentary and holistic approaches. The fragmentary approach involves breaking down the data analysis into small sections; the holistic approach involves finding a sense of the whole that eventually leads broadly to narrative data (Mahmoudi et al., 2012).

During the fragmentary data analysis-process, open-coding was used to record the noticeable patterns and to identify a variety of categories into memos; in the holistic data analysis, axial-coding was used to review the whole data resource in order to tag specific messages which belonged to particular categories. In addition, selective-coding was used to search for missing codes or discrepant evidence (Corbin & Strauss, 1990). Through this process I was able to identify several themes which related to the research questions, and to refine all the content which drew from all the data to support the interpretation. Thus, data from the interview, the questionnaire, the observations, and learners' documents were analysed together, so that categories and themes emerged across the three sets of data. Only when all the evidence enabled a consistent conclusion of how the teacher taught and how learners had learned was the processes of data analysis seen to be complete.

Cohen et al. (2011) asserted that there are no right or wrong answers to the presentation and interpretation of data; there are only stronger or weaker voices to justify the different choices. From this point of view, this study used both emic and etic perspectives intensively to achieve thick, in-depth, and clear description, derived from a convincing analysis, so as to make the entire process from analysis to conclusion both transparent and verifiable.

3.4 Ethical Considerations

Before commencing with the research, I received the ethical clearance letter from the School of Education of the University of Cape Town. I then emailed the teacher who was to be the participant in the research, asking her permission to do research at the school. In the meantime, hard copies of the consent form and information letters were prepared for both the teacher and the parents of the learners (see Appendix 3 for teacher's information letter; Appendix 4 for parents' information letter and 5 for consent form). The information letter introduced and explained my research, and the purpose of the study. It requested the teacher to participate and the parents to give their permission for their children to participate in the research and for permission for the researcher to use audio-and video to record some of the lessons and classroom observations as well as the interviews. The teacher, and the parents signed the ethics forms which indicated that their children would participate in the study and allow me to record the data.

In June 2016, I travelled to China to meet the two teachers with whom I had been corresponding. I introduced myself in person and explained the finer details of my study, the purpose, and the research procedure. I explained that participation was voluntary, and that the raw data would be stored in a locked device that was only accessible to myself. I also explained that all data collected in the study would be confidential, and that no names of any participants in the study would be revealed in the research report, and that only I would have access to the recorded data. I also assured them that there were no known or foreseen risks associated with participation in the study. However only one of the two teachers approached was able to participate.

All the teacher and learners' parents granted informed consent and all consent forms were returned. However, the teacher only allowed me to record two lessons using video, and thus field notes were the main tools used to provide as comprehensible a record as possible of all the details of the teaching-learning activities during the interviews and observations.

3.5 Conclusion

This chapter has addressed the research design, data collection methods, and the data analysis used in this study. The rationale for using the qualitative and ethnographic methods was provided, including the use of emic and etic perspectives. The methods used for the data collection and analysis were outlined, together with the four complementary data collection tools. Finally the ethical considerations relevant to the study and the participants, and how these were ensured, were described.The next chapter presents the data analysis from these various data collection methods.

Chapter 4
Data Analysis

4.1 Introduction

This chapter provides a descriptive account of teaching and learning of number concept in a Chinese primary schooling context. The data were obtained from field work which explored the understandings, perceptions, and experiences of how a teacher teaches, and how learners learn in the Grade 1 mathematics classroom under study.

The chapter is divided into six sub-sections. The first sub-section provides an overview of the various concepts needed to be covered under the national mathematics curriculum for Grade 1 learners, and how these requirements were fulfilled by the teacher. In order to capture this, the textbooks used by the teacher and by the learners in classroom practices were closely examined, and critically analysed. The second sub-section provides a description of the approaches to teaching and learning, and the interactions involved in this between the teacher and learners, and between learner(s) and learner(s). The third sub-section delineates the pedagogic process applied by the teacher for facilitating the acquisition of the concepts under the topic number concept, in the course of which she designed three specific and sequential processes to teach the concepts: concepts introduction, concepts establishment, and concepts consolidation. This is followed by a description of the teaching and learning materials the teacher used for this. The fifth sub-section provides an insight into learner performance—how they demonstrated their internalisation and application of these concepts—by means of assessment tasks, my analysis of the task given, and the methods used by the learner to solve the problems posed by the teacher in the tasks she designed. The chapter concludes with a detailed description and analysis of the findings for each of the sub-sections discussed above.

4.2 Textbooks as Resources for Mathematical Concepts Teaching

China has several versions of learners' primary mathematics textbooks designed in accordance with the national curriculum policy framework (MoE, 2011). Two versions are used widely in schools, one of which is published by the People's Education Press (PEP), the other by Beijing Normal University Press (henceforth, NUP). The PEP is the official professional publishing organisation of the Ministry of Education (MoE), which is engaged both in research focussing on educational books and in the writing, publishing and distribution of primary and other level textbooks. The NUP is not government aligned and publishes in the educational and other fields, such as popular culture. The mathematics learner textbook used by the teacher in the school under study was the PEP version. This officially sanctioned textbook is analysed and discussed below.

The PEP version textbooks are designed by the Course Materials Research Institution and Mathematics Textbook Research and Development Centre. The Grade 1 mathematics textbook has two volumes, one for each semester. The focus of the first semester textbook is on mathematical concepts and organised into eight units, the second semester book into seven units (see Appendix 6 for students textbook).

The units in the learner textbook correspond to the units in the teacher guide book. In addition, the teacher guide book specifies certain extra mathematical concepts which leaners are required to learn (see Appendix 7 for teacher guide book). For example, in the unit *Addition and Subtraction within 100*, learners not only need to learn basic addition and subtraction; they are also expected to learn two-digit addition and digit subtraction. The specific content for what to teach and what to learn is presented in greater detail in the teacher guide book. Therefore, from the learner textbook and teacher guide book, I inferred that the authors of the textbook had designed learning to focus on the concepts of Numeracy and Algebra at Grade 1 level. Thus, these Chinese, MoE published textbooks not only define the mathematical content, but also highlight the key concepts to be covered at Grade 1 level.

In order to help learners fully grasp and apply each mathematical concept, the teacher used a combination of relevant teaching materials and teaching methods appropriate for Grade 1 learners based on the concepts selected. The teacher stated that the concepts taught, and the order in which they were taught, were determined by the learner textbook and the teacher's guide. In light of this, it is crucial to mention the essential mathematical concepts covered in Grade 1 by first analysing these text-books in detail.

The observations showed that the teacher independently designed and covered (sequencing and procedure) the contents rather than religiously following the teacher's guide and the learner textbook. Her teaching content was more specific and detailed in terms of what contents should be covered based on a gradual order of levels of complexity. However, the learner textbook was often used for classroom exercises. Hence, the teaching-learning activities followed in the classroom not only focused on the textbooks, but also relied on the teacher's instruction design. Therefore, in the following section, a description of how the teacher taught, and the ways in which learners were observed to be learning mathematical concepts, is discussed.

4.3 Dominant Approach to Teaching and Learning

Four dominant principles appeared to inform the teacher's teaching approaches. Firstly, the teacher guided and structured the knowledge she presented to the learners. Then the teacher used a *learner-centred* [1] approach. The teacher also guided her learners' exploration with dialogue activities. Finally, the teacher cultivated mathematical thinking in her learners by means of a variety of well-designed tasks and exercises. Each of these aspects is discussed in detail, and include excerpts taken from classroom observation and the two hour interview with the teacher to illustrate each principle. However, the teacher used controlled dialogue activities the most in facilitating and guiding her learners' classroom participation, and used other kinds of methods in guiding learners to engage in the specific ways of mathematical learning.

4.3.1 Teacher guidance and structuration of knowledge

The first principle of the teacher's teaching approaches that emerged very clearly involved the various ways she guided her learners and structured mathematical knowledge for them. The teacher played the role of guide, and organiser in creating various contexts aimed at guiding learners who were actively engaging in mathematical activity in the form of a variety of tasks and activities. At the same time, she paid particular attention to the ways in which she structured the questions to guide learners in developing abstract mathematical thinking, and sometimes prompted learners to respond by her appearing to make mistakes. This strategy was designed to get learners to develop solutions independently. However, although the teacher paid a significant amount of attention to her learners' learning in the course of these activities, at the same time, she was controlling the instruction sequence. The reasons for this are discussed in detail in Chapter 5.

The teacher had explained during the interview the reasons for the guiding role she saw herself playing in her mathematics classes, while maintaining some measure of direct instruction:

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[1] Learner-centerd approach derived from national curriculum policy. Policy emphases learning is dramatic, active, and personality processes, teachers should give enough time and space to let students themselves to experience the learning processes (MoE, 2011).

In my class, I am the leader. Learning is ordered by the way I teach…by focusing on what I say and how I speak in the classroom...I was asking questions to guide learners to think independently rather than providing the results directly. Therefore, asking a good question is a good organizer and guide… These questions were designed in accordance with the teaching content and objectives, and these questions string together for controlling learners learning process.

This extract from her interview shows the teacher's perception of herself as playing a combined guiding and controlling role in terms of the structure of the lesson. I observed that this role did become flexible in some respects in the classroom: the teacher created various contexts to guide learners to engage in mathematical activity, and in an attempt to mobilize some degree of self-regulative learning. She provided adequate space and time to learners to try to solve a problem independently, in turn, monitoring and giving guidance to learners' responses. The following excerpt, involving the concept of subtraction-borrowing, highlights the guiding and organising approaches. The teacher had designed the task with the purpose of establishing whether learners had acquired the concept or not.

T: Let's take a look at operation of 67-50-8? Who can tell me how to do it?
L1: First calculate 67 minus 8, and then 50 minus their difference.
T: Right?
Lc: (Chorus) Wrong.
T: Let's analyse why she was wrong? If we write down what she said, what does it look like?
Lc: (Chorus) 50 minus 67 minus 8.
T: (write down the formula of 50-(67-8)), Can anyone tell me how to calculate this?
L3: First calculate 67 minus 8, and then 50 minus their difference.
[……]
T: Very good. Please write down this example beside your topic and the operation rules as well. Now, let's move on to the next exercise.

When a learner provided the wrong answer for a way to solve the problem of subtraction-borrowing, the teacher decided to use the learner's answer as a counter-example as a strategy to guide learners to understand the concept; after she had judged the learners to have acquired the skill, the teacher asked them to write down the operation of problem-solving in their learner textbook.

One can conclude from this that teacher guidance was mainly manifested in, and organised around, specific questions. The teacher used a series of questions for eliciting her learners' existing knowledge and guiding their thinking process. While the teacher specified the questions that were intended to simplify the exercise in a step-wise manner, most of the learners, in answering the questions, appeared to continue to think deeply and finally devised a method for solving two related tasks. During this activity the learners' thinking appeared to develop, or were in the process of developing, from a lower to a higher level through specific visual cues learners observed on the blackboard, and they updated this to abstract thinking. The teacher asking her learners to write down the steps of the problem-solving in their learner textbooks was intended to consolidate the mathematical thinking processes and abilities involved, such as logical reasoning and problem-solving. However, although the teacher made momentary adjustments to the direction and structure of her teaching in accordance with the learner's wrong answer, the instruction sequence was still led by the teacher. The guidance was consistently conducted and developed in accordance with the teacher's questions. This was also observed for the sequencing of the contents of the lesson by the teacher.

From the teacher's account of her teaching strategies in the interview, she had a clear position and perception about taking on the roles of *leader*, *organizer* and *guide*. She did not exclude a lecture/transmission style of teaching and ultimately she controlled the teaching sequence, and the order of the steps she intended to follow. For her the key to maintaining overall control of the lesson was to design specific kinds of questions or tasks that she considered could help to guide learners to participate in their learning. This opportunity she intentionally provided for learners to participate provides an entry point to discuss the nature of the learner-centred approach the teacher used.

4.3.2 Learner-centred approach

Another dominant approach I observed was that of learner-centred teaching, but one that was always controlled by the teacher. There was a relaxed autonomous learning environment as regards classroom practice, and learners' learning had obviously been significantly strengthened as a result of this. According to the curriculum policy (MoE, 2011), learner-centered teaching approach involves self-experience, self-explanation, and self-exploration. In observations, self-explanation teaching focuses on learners' expression of their logical reasoning and problem-solving procedures. Self-experience teaching focuses on learners through concrete operations in order for them to acquire an experience from concrete to abstract, and self-exploration teaching focuses on through concrete operations experience to understand how the concepts be formatted.

The teacher in her interview appeared to be describing her kind of approach to her learners' learning as she understood it from the teacher's guide, and from curriculum policy which informed both teachers' and learner's guides, although she did not necessarily fully agree with this approach for reasons which will be discussed in the analysis in Chapter 5:

> *…the teachers' guide is to help learners to operate the mould, observe the pictures, in order to understand the meaning of the concept by learners themselves, and then classwork and homework to reach and consolidate new knowledge*.

This statement suggests that the teacher was aware of the possibilities for learning to be learner-centred, and that this learner-centred learning, as she understood it, was currently the accepted official position as promoted in the curriculum policy document. In her view learners-centred learning was mainly manifested when:

> *…the learners themselves are able to operate, abstract mathematical concepts, and understanding the features of these concepts*.

This suggests that she saw learner-centred learning in terms of results, or evidence of learners having mastered certain concepts, rather than as part of a teaching/learning process. The teacher's classroom practice reflected her own beliefs and perceptions regarding learner-centred learning. To further explore what meaningful independent learning activities were in fact taking place as part of a teaching/learning process, I focussed on the teacher's classroom activities.

The lesson activities involving numeracy within 100 were selected for observation and discussion of learner-centred teaching activity as I, education theorists, and the Chinese national curriculum policy designers understood it, and the extent to which this form of learner-centred learning was taking place in the classroom under study:

T: …who can tell me how to verify it?
S1: To count how many sheep in one group.
T: OK, let's try this method, here I would like to invite ten learners to count for us, and everyone just count one group sheep, you five come in the front of here.
Lc: (the learners are counting individually)
T: How many did you count?

L1: Ten.
[……]
T: Let's look at the picture together, I invited another ten learners to count sheep, after their counting, how many group of sheep they counted?
Lc: (chorus) Ten.
[……]
T: Two groups is consisted how many 10?
Lc: (chorus) double 10.
T: Decuple 10 is?
Lc: (chorus) One hundred.

In the process of the teaching and learning of the concept of numeracy within 100, the teacher first asked a group of learners to present a way of verifying the given answer. Through a practice process she guided learners in what things they needed to pay attention to, such as understanding that 10 times 10 equals 100. This practice was clearly intended to provide an operational base or resource for learners to engage in further numerical activities.

During this counting process, learners' thinking and concrete actions had definite purpose, while the teacher only provided a methodological guide. Learning was based on a process of concrete counting to discover and explore the concepts. The teacher provided space and time for learners to go through learning experiences in which they discovered a way to solve the problem, and for their initiatives to be mobilized. It can therefore be concluded that some form of learner-centred teaching worked here in a process of operations, experience and ideas exploration, and that these learner activities constituted the learning process. The following section describes and demonstrated the self-exploration approach as used by the teacher in greater detail.

4.3.3 Guided exploration and dialogue activities

As discussed above, the teacher guided learners to experience operations in order to help them acquire number concept. In this excerpt, the teacher's guiding and control of the steps of the lesson could be said to focus more on learners' self-exploration. In this section, I elaborate on how the teacher, through dialogue teaching-learning activities, helped to guide learners' concepts exploration. In addition, in the dialogue activities, learners' self-explanation seemed to become a conventional way of learning in this Grade 1 mathematics classroom.

The teacher explained her teaching and learning design:

First the important thing is teaching, which combines what the teacher's teaching and children's self-learning; second is to operate by learners themselves. Some mathematical concepts are very abstract; if learners cannot understand, I think teacher as guide needs to be exerted.

From her interpretation of self-learning, it can be seen that the teacher perceived learning as a form of guided exploration by learners themselves, and that she advocated that learner's learning needs a process of operation experience.

The following excerpt shows the teacher teaching and the learners learning the concept of two-digit comparison:

T: Think about 42 and 37, which one is less and which one is greater?
L1: 42
T: So then 37?
L1: Smaller.
T: What symbol do you think to fill in?
L1: Greater than
T: Good, can you tell me why?
S1: (Silence)
T: Who can help him?
L2: 42 is consisted of four bundles of sticks, add two single sticks, 37 is three bundles of sticks, add seven single sticks.
T: Everybody understand?
Lc: (chorus) Understand.
[……]
T: What we are comparing at?
Lc: (chorus) The tens.

This shows, in the process of teaching and learning the concept of two-digit comparison, the teacher proposing a task to compare 42 and 37. The teacher's teaching patterns involved learners seeking the answer, teacher and learners collaboratively both proving the methods procedure and exploring the logical thinking involved. The teacher's teaching approach employed a pattern of one-to-one dialogue activities.

The teacher gave learners the opportunity to use their own words to explain, and she patiently listened to her learners' responses. It can be seen that, although the teacher selected a learner to answer the question, the intention was for all the learners to be involve in working out the problem. In asking individual learners questions, and moving on to guide the class as a whole to make the thinking. Therefore, the basic teaching-learning activities were the interactions between teacher and the whole class, where teaching was focused on the whole class rather than on an individual learner or on group activity/ies.

It can also be seen that in the process of classroom practice, learner talk occupied most of the instruction time, while exploration of ideas was the main teaching and learning approach. That is, one learner explained the ideas to the class as a whole, then other learners listened to the demonstration of that learner's answers in order to compare or reflect on their own ideas, and then the teacher's judgment was applied to adjust or confirm their ideas.

However, the implicit contradiction in this process resides in the fact that the self-exploration or self-learning approach did not seem to be completely integrated with, or complementary to, the simultaneous control activities. It seemed from the teacher's teaching that the foundational idea supporting her practice was in fact that a guided exploration learning approach involving self-learning may be more of a supplement to teacher control and the structured guiding approach than a flexible self-exploration and/or self-learning experience for the learners. The reasons for this approach are discussed in Chapter 5.

4.3.4 Cultivating mathematical thinking through "accumulation of experience" [2]

The teacher seemed to believe that teaching mathematical concepts at Grade 1 level involved helping learners through a process of experiencing and developing thinking through using concrete objects. The teacher designed different activities to guide learners to accumulate different exploration learning experiences. These included observation, performing specific tasks and exercises, conjecture verification, as well as guiding learners' thinking by asking well designed and thought-through questions, all related to their everyday experience and to familiar objects. In this way the teacher seemed to be attempting to mobilise the learners' mathematical thinking through a process of ensuring each learner started accumulating mathematical experiences. These experiences seem to establish confidence in learners, which in turn helped them to understand that there are many and creative ways to approach the same problem.

The accumulation of experience on the acquisition of mathematical concepts to be closely integrated with mathematical knowledge and thinking, so as to make sure that learning may not be a merely formal learning activity, but may be always at a higher thinking level. Therefore, the accumulation of experience approach, particularly at Grade 1 1evel,

[2]Experience accumulation derived from the interview where the teacher stated that teaching should provide the opportunities to guide learners to accumulate the different learning experience.

seemed to be a way to communicate mathematical concepts and thinking. Through the different dimensions of tasks and exercises, learners may experience acquire concepts in many ways.

The teacher said in the interview:

> *The curriculum emphases mathematical experience…I think this is the most important things in teaching design…So, I feel that teachers should pay more attention to the process of how to accumulate experience (for this) concerns the mathematical knowledge of implementation and application, and pay attention to cultivate the mathematical thinking.*

The teacher seemed to believe that, in order to encourage learners to stay involved in the process of learning, she needed to spark and nurture her learners' mathematical interest; and ensure that this would be followed by learners thinking in a continuous and uninterrupted process. To ensure learners' continuedinvolvement the teacher used exercises designed for this purpose; these seemed to enhance learners' interest and sustain their desire to participate in learning.

The teacher regularly designed specific exercises/tasks to guide learners' thinking. For example, in the lesson on numeracy within 100, the teacher asked a question to elicit from the learners ways to estimate a group of number, which initiated the experience of choosing—and the reasoning accompanying this—which way to present 100. The purpose was to allow learners the opportunity to discover the 10 numeracy system as the basic knowledge and means to develop a new concept. Therefore, in order to ensure that learners built an appropriate representation of 100, the teacher designed an activity on how to use fingers to present the concept of 100, the excerpt is below:

T: Can you find a way using the fingers to count 100? …how can you use fingers to count 100?
L1: Both hands count ten times.
[……]
T: Any other ways? Only count both hands of one child?
L3: One finger represents a one ten. Ten fingers are 100.
T: Very good, let's go back together to find ten children to count ten hands.
[……]
T: Now we are going to count based on ten numeracy method. One ten is?
Lc: (chorus) 10.
[……]

T: We found that decuple 10 is?
Lc: (chorus) 100

The teacher designed a method of using fingers as the tool to assist learners to think mathematically in different ways. Learners started from an image of both hands, with a total of ten fingers, to establish the representation of the number 10. Then the teacher guided learners to gradually expand this representation from an individual performance to a group performance in order to establish the concept of 100. Finally, the teacher moved back to learners counting individually so as to deepen their understanding of the concept. Through these processes of practice and counting the teacher guided learners, using these experiential activities to shift their thinking from a concrete experience of 10 to a mental arithmetic of a 10-base numeracy system calculation.

With this purpose in mind the teacher designed various tasks and questions to help learners understand new concepts. This teaching approach seemed to be based on a learners' explanation, interpretation of logical ideas and on the counting skills involved in the concrete operation that moved from operations towards concept acquisition. The teacher provided learners with the opportunity to explain their own ideas. Sometimes, when a learner's answer was wrong, the teacher would give that learner another opportunity to correct her or his answer. This opportunity would take the form of an operation that the learner had to perform in order to find the answer; at other times the answer would be elicited by the teacher by asking other learners to help with finding the answer. Therefore, a teacher inviting learners to help in providing a mathematical concept or rule, or solving a mathematical problem, or adopting a concrete operation approach, probably helps learners to cultivate diverse and creative ways of thinking about the same problem. Through this kind of teaching and learning process, learners not only have an opportunity to freely express their thinking, but also to accumulate learning experience.

It can be inferred that the teacher deliberately provided her learners with a mathematical experience which stimulated their thinking, and provided the opportunity for them to accumulate experience in doing mathematics; this seemed to involve a process which integrated experience accumulation, knowledge application, and mathematical thinking. More specifically, these four dominant approaches reflected the three specific concept mediation phases. In the process of these mediation phase teaching activities, learners were directed along certain learning paths towards acquiring mathematical concepts. In the next section, I analyse the ways in which the teacher designed certain mediation teaching approaches aimed at guiding learners to engage in learning concepts.

4.4 Phases of Concept Mediation

This section presents a detailed exploration of the ways in which the teacher taught and how learners learned in terms of the three phases in the mediation of mathematical concepts that dominated the teacher's instructional approach. During the interview, the teacher reported that for her the key to this kind of teaching approach was to think about how to design the structure, procedure, and the questions in order to guide the learners' learning. The teacher's instruction design was not detailed in the textbooks—either the learner's book or the teacher's guide—but seemed to involve a process of combining the mathematical context of knowledge with the process of concept acquisition in order to help learners to acquire the concepts. From this point of view, the teacher generally divided teaching and learning into three phases: concept introduction, concept establishment, and concept consolidation.

4.4.1 Concept introduction

The concept introduction phase was often used at the beginning of lessons to attempt and ensure that learners would be able to carry out the new concept learning activity. This approach was designed to make it possible to guide learners into new concept learning. The way the teacher achieved this was by designing the specific context to connect the specific concepts she wished to introduce with what the learners already knew. In the phase of concept introduction, the most common approach was to introduce the new concept by building on learners' existing and previous knowledge through a series of questions, and by reviewing their everyday knowledge and experience.

Generally concept introduction seemed to be designed by the teacher to start a lesson, after which she guided her learners through a process to assimilate this new knowledge. This was the most common approach and sequence in most lessons. At the beginning of each lesson, the teacher would refer to learners' prior knowledge to help them, or prepare them to, actively integrate new concepts into their existing understanding. This seemed to not only help learners assimilate new knowledge, but also to effectively review already mastered concepts and existing levels of previous knowledge understanding. The following excerpt demonstrates the teacher's use of this approach.

T: We already learned counting, and we know a former number is always “something” than a latter number?
L2: short one.
T: … now I’d like to ask in front of 46, all the numbers are “something” than 46?
L3: Less one.
T: All less one? Think about it, all the numbers in the front of 45 are less one? If I say all the numbers in the front of 46?
L3: All less than 45
[……]
T: Good, can you summarize from which number to which number are less than 45?
L8: From 1 to 44 are less than 45.
T: But I think there is another number which we learnt.
Lc: (chorus) Zero.
[……]
T: … in the morning, something happened in Sheep village. Xiyangyang and Huitailang were arguing about something, let’s take a look at (open multimedia).
[……]
T: This is what we’re going to learn; it is called “Two-digit Comparison”. Everyone think about whose sticks are more and whose less? Let’s discuss together.

At the beginning of her teaching of the concept of two-digit comparison, the teacher proposed a filling in number task: _, 45, _. The task was designed for learners to recall their prior knowledge in order for them to prepare to connect and compare their existing knowledge with the new concept. After the teacher and learners together reviewed their prior knowledge, the teacher immediately represented an cartoon story to introduced the new concept.

In the process of this reviewing, the teacher’s teaching approach moved from an interactive activity of teacher-whole class exchange to teacher-only speaking. Because the knowledge of estimating the number 100 had been covered before, the teacher expected that learners would use their prior knowledge to do the estimation. However in this teaching process, learners did not seem to understand the meaning of estimation. As a result, the teacher considered it necessary to re-explain how to do estimation.

According to the teacher in the interview, the purpose of the re-explanation in this instance was to consolidate and expand on the concept of estimation. It was intended to pave the way for later comparison study. Once the learners had mastered the estimation, the teacher immediately set up a context to lead them to learning the new concept. In this instance, the teacher used an everyday cartoon story representing an experience familiar to her learners, and the visual representation was intended to enhance learners’ intuitive understanding, and harness their imagination in terms of their everyday context, and so both stimulating their interest and making a link between their everyday experience and the mathematical concept.

Therefore, by inspiring learners to think by means of the teacher asking questions, she enabled her learners to voluntarily enter into group discussion. The teacher designed each new lesson by starting from concept introduction, reflecting strong and explicit control of the teaching and learning sequence. A strong guiding process was established by using specific questions designed to lead learners into thinking about the concept and linking it with their everyday experience.

4.4.2 Concept establishment

After introducing the new concept, the teacher would enter what seemed to be the critical phase: concept establishment. In the concept establishment phase, the teacher mainly used, or modelled, the reasoning process they needed to use to form a concept. It is also an indirect teaching approach to designing a structured process to allow learners to explore and experience the concept's features. The teacher designed the specific concrete operations intuitive activity to motivate her learners' thinking, and in order to guide them towards understanding the new concepts.

According to the teacher in her interview, the intuitive activities were intended to motivate her learners' thinking in such a way that their learning process, on the basis of their perceptions, moved from the concrete to concepts of abstraction. In this process learners revealed their understanding of the concept of property, leading ultimately to the establishment of concepts. The teacher described this strategy in the interview:

> *I design learning a new concept to start from hands-on operating, in order to help learners in a specific context to experience how a concept can be established...operation needs to follow the teacher's guide; concept establishment is from the problem-solving of operation to understand mathematics principle, to master mathematical skills, to abstract concepts and its features*.

It can be seen that, in the teacher's view, concept establishment requires and includes the sequential processes of operating, experience, and concept formation. Therefore, in the teacher's class she encouraged learners to operate, to imagine, to speak, and to try comparing one learner's answer with other learners' explanation.

The excerpt below was selected as an illustration of the operation teaching approach to guiding learners to acquire the concept of numeracy with 100.

> T: Can we use the method of estimating sheep to estimate sticks? The sticks are in my hands.
> Lc: (chorus) One, two…ten.
> [……]
> T: Let's take a look at both of my hands (teacher now shows leaners a couple of bundles of sticks).
> Lc: (chorus) Oh, aw! More than a lot.
> [……]
> T: I estimated there are 90 sticks in my right hand. I would like to invite a child to verify it, who wants to give us a head count? You count, so the other learners can see whether she is right or not?

Before this lesson, the learners had only learned numeracy less than 20; therefore, the teacher designed a specific operation of counting sticks in order for them to conceptualise numeracy with 100. At Grade 1 level, learners use sticks as the specific tool for counting and for understanding the 10-base numeracy system. I elaborate on the counting sticks teaching method in the following section. The teacher designed the concept establishment processes using the counting of sheep and counting sticks. For the counting of sticks process, the teacher divided the total bundle of sticks into two groups of sticks, one for each of her hands: in her left hand she had 80 sticks, and in her right hand 20 sticks. The teaching-learning activities were conducted around the counting of the sticks by the teacher and her learners. After counting, the learners established a number sense of 100, and also corroborated the quantity relations between 100 and 20.

In this way, the sticks became an abstract concept embedded in an intuitive operation. Learners were familiar with sticks from their everyday context, and these sticks provided a tool to guide them to establish, on a more abstract level, something about the new concept of 100. In addition, the counting sticks represented the10-base numeracy system. Thus, through counting process, learners ultimately acquired the abstract concept. This process guided learners from a real/concrete activity context in which they learned to use conceptual tools, through to thinking by doing, thence to analysis, and also to everyday life problem-solving.

It can be inferred that the teacher's method for concept establishment included learning through hands-on experience, and thus the use of application to train and develop learners' consciousness of mathematical concepts. Operate mainly refers to self-learning and exploration. In other words, the teacher seemed to consider this as an appropriate and effective method to establish the understanding of concepts. During the phase of concept establishment, the teacher focused not only on the connotations of the concept itself, but also on its extension as a way to prompt learners' full understanding of concepts. This method is based on the idea that teaching and learning can be considered as a process of development from intuitive contextualised activities towards concept materialisation, through mental abstraction (Vygotsky, 1978).

Therefore, at the concept establishment stage, learners did not just learn a new concept; they also developed their logical thinking. For example, learners used counting tools to establish the perception of the 10-base numeracy system. Meanwhile, during the process, the teacher designed questions organically to guide the learners to paying attention while operating and thinking. In this way learners could experience the process from the specific concrete operation toward abstract thinking, while the teacher's guiding and controlling of the procedures completed and strengthened the instructional activities between the teacher and whole class.

4.4.3 Concept consolidation

In the process of clarifying and establishing the meaning of new concepts, learning enters a phase concept consolidation during which learners, based on the initial establishment of new concepts, still need to use a variety of methods to promote the concepts in order to retain the specific mathematical thinking structure. In the process of concept consolidation, learners' continuous use of the concepts in a different context, continues their deepening of their understanding and memory, so that the new concept can be consolidated in their minds.

The teacher designed a consolidation phase to review and practise the concepts just learned in class, generally through the method of doing exercises. As mentioned above, the teacher believed that learning mathematical concepts involves achieving understanding and consolidating the meaning of mathematical concepts through class work. In the course of my observation of five lessons, the teacher's teaching demonstrated her views on teaching and learning mathematical concepts she had expressed during the interview. She emphasised her view that class work is the most important way to consolidate concept acquisition in everyday class.

In these five lessons it became clear that the last section of instructional activity was class work. The main type of class work was algorithm diversification, and precise differentiation. Algorithm diversification refers to learners solving a problem by using different mathematical methods and thinking. These Grade 1 learners seemed to need to use a variety of methods to promote and retain the concept in their mental structure. By their constantly using the concept to deepen their understanding and memory, as was discovered in the analysis of learners' test papers, it appeared that the concept had come to be fully mastered by learners (see section 4.6.1).

The following excerpt is an example of algorithm diversification:

T: who will talk about how do you solve the problem?
L1: Behind 44 is the 45, above 45 is the 35.
T: Well, is there any other methods?
L2: From left to right, the ordering of the tens is 5-4-3, and the ordering of the units is 3-4-5.
T: Very good, any others?
L3: under the 44 is 53, the right of 53 is 54, the right of 54 is 55.
T: Well, this method is a bit slow, other methods?
L4: On the left of 44 is 43, the above of 43 is 33, 33's right is 34, 34's right is 35.
T: Ok, any others?
L5: Above 44 is 34, on the right of 34 is 35.

The excerpt was selected from a lesson on the concept of a number map. In the concept establishment phase, the teacher guided learners to find the laws of the number map, such as that tens are the same in the same row. Then the teacher designed the different tasks to consolidate this knowledge. As the excerpt illustrates, the teacher designed the task for learners to discover what number is in the top of 45 on the number map. The teacher asked five learners to explain the problem-solving methods they used to arrive at the answer, and encouraged learners to come up with different methods to solve the same problem or question, and gave them opportunities to explain their ideas. During the exercise it became clear that learners did indeed use their existing knowledge and their own methods to solve the problem.

The learners' responses showed that they had their own interpretations. Though some ideas were not as efficient as others, the teacher nonetheless gave them affirmation, indicating that she took into account differences between individuals. It was evident that the teacher implemented two approaches in her class work: to promote algorithm diversification, and to further encourage her learners to think independently, thus achieving active learning and developing learners' creative thinking abilities.

Another type of class work was that which practised precise differentiation. The excerpt shows the teacher using contradistinction to help learners avoid confusion.

T: So when we compare the two-digit, what thing we should look at?
Lc: (chorus) The tens.
[……]
T: We already know how to compare two-digit numbers. The first step is to look at the tens. Look at them here (write down 100_99)…zero is smaller than nine. According to this logical thinking, my deduction is that 99 is greater than 100. Am I right?
Lc: (chorus) No, you are wrong.
T: Why was I wrong? Look at the tens, 0 is smaller than 9, 9 is greater than 0, so 100 is smaller than 99. How my deduction is wrong? If you think so, tell me how do you think?
L11: Because tenfold 10 is 100, 99 have nine fold 9, and one signal 1.

The excerpt was selected from the lesson on two-digit comparison. The instruction was designed using two steps. The first step was to summarize the rule of two-digit comparison. The teacher guided learners step-by-step in remembering the previous knowledge, and then moved on to focus on questioning and helping learners to correct their understanding and make their expressions more complete and specific.

In the second step, the teacher used comparative methods to clarify for her learners the relations and differences between confusing concepts. Thus the teacher first designed a counter-example (such as a comparison between100 and 99) to verify the prior concept. The teacher started to help learners apply their prior logical thinking by showing them a counter-example; the learners all disagreed with her results. Then the teacher devised a number of teaching steps to guide learners to fully understand the concepts in order to promote her learners' divergent thinking. Her teaching allowed her learners to further refine the concept through conceptual distinction, and to deepen their understanding.

Throughout the consolidation of concept, the basic teaching and learning approach was focused on learners doing exercises under the teacher's guidance. Thus, firstly, the teacher allowed learners, and encouraged learners to use their own and different problem-solving methods. Secondly, learners explained their methods, and the teacher then guided them in the use of a specific method to solve this problem. Moreover, some learners appeared to take the initiative to think about the problem in several different ways.

Thus it can be seen that in this lesson the teacher used different approaches to transmit knowledge, and gave learners the opportunities to participate in classroom practice. Similarly, the teacher designed and used different resources to assist these teaching approaches, such as multimedia and counting sticks. Her use of resources is discussed in the following section.

4.5 Teaching and Learning Resources

As described above, in the Grade 1 mathematics classroom under study the teacher designed specific questions and activities to guide learners' concept acquisition. To augment this teaching method, and to assist learners' concept acquisition, the teacher used two kinds of teaching resources which can be categorised as symbolic and material resources (Miller, 2011a). An example of a symbolic resource would be language. The teacher frequently used both narrative and conceptual language to guide her learners' learning. Material resources at primary school level include multimedia, the blackboard, and counting sticks. The teacher used these two kinds of resources to assist different kinds of instructional activities, as is described in the following sub-sections.

4.5.1 Symbolic resource

The teacher used narrative and conceptual language: narrative language in the concept introduction phase with the aim of setting up an everyday context to introduce new concepts. She applied narrative language in a concrete way in order to evoke a mathematical experience in the form of a story or an everyday context. Once she had introduced the concept using narrative language, she used conceptual language to describe the mathematical concepts, and pose a mathematical problem. Both forms of language together constitute an important tool for communicating and transforming mathematical knowledge (Karpov & Heywood, 1998).

Narrative language

As has been mentioned, narrative language was used in the concept introduction phase in the form of everyday knowledge to introduce the concepts. In her interview, the teacher expressed the belief that, when teaching mathematical concepts in Grade1, her choice of language should be guided by certain criteria in terms of register and vocabulary appropriate to Grade 1 level:

> *… trying to use some specific language which is close to learners' everyday life and age, and pay attention to use clear and concise language to teach mathematics. For instance, when teaching the number one, first show pictures of a flower, then let the learners use their language to talk about what is it? After*

learners abstract the number one, then let the learners express other examples from their everyday life.

In this way the teacher advocated using narrative language to assist the teaching of mathematical concepts and connecting mathematical ideas to learners' everyday lives. In all five lessons I observed, the teacher used narrative language mostly during the concept introduction phase. The following excerpt illustrates how narrative language was used, together with a visual cue, in the cartoon story to introduce the concept of two-digit comparison. The teacher designed a story at the beginning of the lesson.

> T: One morning something happened at the entrance to the village, Xiyangyang and Meiyangyang (sheep's name) were debating something, let's look at what exactly happened. Who can read for us?
> L1: I have 42 sticks, I have more.
> L2: I have 37 sticks, I have more.
> T: …Xiyangyang and Meiyangyang were debating about the sticks, who has more sticks than the other? Are 42 bigger or are 37 sticks bigger? This is a new concept of two-digit comparison that we will
> learn today.

The teacher used narrative language to present the cartoon story, and selected a learner to read the story for the whole class. After the story presentation, the teaching and learning process followed a set of specific questions to complete and consolidate the processes of listening, reading, and thinking. The teacher's use of narrative language seemed to attract learners' interest and imagination, and to motivate them, or make them open to, the acquisition/internalisation of the new concept. The teacher had introduced the concept of two-digit comparison by embedding it in this cartoon story.

In introducing the new concept, the teacher applied language and metaphors familiar and accessible to her Grade 1 learners, trying to find appropriate examples to associate the concept with the learners' everyday lives. This strategy appeared to stimulate learners' interest in learning the new concept. Thus it can be inferred that the teacher applied appropriate narrative language primarily in order to invoke mathematical ideas that already existed in learners' prior learning and everyday experiences in order to prepare the ground for establishing the mathematical concept. She used this strategy in all lessons where she introduced a new concept.

Conceptual language

The difference between narrative language, conceptual language is used to explain a particular mathematical problem or way of thinking. The teacher often used this kind of language in concept establishment and class work phases, and explained in the interview that her use of conceptual language was focused on explaining/transmitting mathematical knowledge:

> *My mathematical instruction language is mainly focused on mathematical description. It unlike Mandarin, does not have too many adjectives to describe; it just uses simple and short language to describe the particular mathematics information*.

In the teacher's view, conceptual language is used to focus on the explanation of mathematical problems, and this involved using simple language to connect the concrete narrative with more abstract mathematical thinking. She understood that conceptual language was not like narrative language, which uses many words and/or stories to illustrate and make the problem more real, and/or relate it to learners' everyday lives. Conceptual language is pared down: it uses simple and short sentences to transmit mathematical information.

I observed conceptual language dominating classroom practice, particularly for establishing and consolidating new concepts. Conceptual language was always tied to a particular mathematical problem, and focused on using simple and abstractive words to express the mathematical idea or concept, and how to use it in thinking about mathematical problems. More specifically, in her classroom practices the teacher used conceptual language for questioning and to help her learners build their logical thinking processes:

T: Can you summarise it? From which number to which number are all less than 46?
L8: From 1 to 45 are all less than 46.
[……]
T: But I think there is another one which we already learnt?
Lc: (chorus) 0.
T: who can re-summarise it?
L9: 0 to 45.
T: What? These are all…?
L9: …less than 46.
T: Can you say it completely again?
L9: Numbers from 0 to 45 are all less than 46.

The teacher's conceptual language was mainly focused on minutely examining and consolidating learners' responses to a series of questions, such as "Can you summarize it?", "From what to what are less than 46?". Her conceptual language was also focused on logically proving or disproving a response, from a specific mathematical perspective, to solve the problem. Following the minute examination, learners' mathematical thinking correspondingly improved in two ways. The first way was their attaining higher level functioning, moving from speaking words to explaining in detail the principle independently—without the teacher's prompting. The second way was their moving on to sum up the rules independently. For example, after the exercises learners needed to summarize a specific mathematical principle or law by themselves.

Therefore, the teacher's conceptual language was focused on a clear and simple way of conveying an idea. Her conceptual language kept the learners thinking in certain ways, so that the whole instruction sequence was compact and focused, and maintained a high degree of learner participation. In addition, learners' talking also dominated when they were invited by the teacher to respond and in their talking, their mathematical thinking gradually improved with regard to their expression and explaining of their thinking, and the derivation process.

In all five lessons, the dominant language was conceptual language, and the teacher designed the questions to allow all learners to participate in the teaching-learning activities and to make the relevant mathematical knowledge and concepts clear. In each lesson, the proportion of conceptual language to narrative language was far larger. In other words, the teacher used a particular vocabulary and short sentences to express abstract mathematical concepts. Narrative language was used mainly during the start of the instruction phases, where its main function was to build a specific context, so as to lead to conveying and acquiring a particular concept. Learners' language was focused on the description of their mathematical thinking, such as explaining their reasoning processes rather than on merely providing correct answers. During the instructional activities the teacher also used material resources to assist her teaching.

4.5.2 Material resources

The teacher used two kinds of material resources: multimedia and the blackboard. She used multimedia to guide and encourage the learners to participate in teaching-learning activities. She designed pictures to present in the multimedia which connected learners' everyday contexts to specific mathematical problems, thus complementing her use of symbolic resources. The blackboard was used to highlight the mathematical content and knowledge application procedure. In addition, Grade 1 learners, together with the teacher, used counting sticks to help themselves to understand number concept.

Multimedia

In the teacher's classroom, multimedia were used to create the exploration context. Firstly, the teacher used multimedia to strengthen learners' interest and spark their motivation, as well as to stimulate their enthusiasm for learning.

For example, in the teaching and learning concept of two-digit comparison, the teacher showed a picture which combined the everyday context with the mathematical problem. At the beginning in this lesson, the teacher first told a story (See 4.5.1. Symbolic resource). After the teacher began to narrate this story, and posed the question, she showed the image (see Figure 4.1) to learners. In Figure 4.1, two cartoon characters are having an argument *"I have 42 sticks, I have the most. I have 37 sticks, I have the most"*.

Figure 4.1. Multimedia presentation of cartoon story

The teacher asked a learner to read the arguments for the whole class. After the learner read the two argumentative statements made by the cartoon characters, the teacher continued to ask the whole class to look at the picture, and read the words together. Then the teacher gave learners time to think about how to solve the problem presented in the cartoon. Learners all raised their hands, and seemed eager to offer their own solutions.

In this instance, the teacher used a cartoon image to create a context in order to help learners to observe the context, and by so doing, to solve the problem. The images and story seemed to inspire the learners' participation in an everyday context, so mobilising their learning, and motivating them to think, and to think logically. Learners' responses were very positive: they all raised their hands, and were keen to answer the teacher's questions. Such was the enthusiasm and motivation of some learners that they stood up with their hands raised to answer her questions.

It seemed from learners' enthusiastic responses that the contextualisation had stimulated and mobilized their activity. Learners seemed motivated to explore and solve problems. In this instance, multimedia could be said to have assisted in creating mathematical context and strengthening class motivation. Learners moved from passive listening to active participation. The multimedia also seemed to arouse learners' attention, imagination, and enthusiasm. Learners were relaxed and happy and open to acquiring new knowledge and new mathematical concepts.

However, in the course of the observations, I noticed that, although the teacher usually presented everyday context images for introducing concepts, multimedia seemed to only provide the concepts, and specific context, especially in the introduction phase of the lesson. The teacher explained her desire to make more use of multimedia and her limitations to using this particular way to transmit and develop knowledge:

> *Multimedia is infrequently used because of my limited computer skills. I would like to design some good courseware that I can use, but I can't. Because of my limited computer skills.*

Although the teacher was able to use multimedia to help learners to acquire concepts, she expressed a wish to develop courseware to assist her teaching. However her lack of computer skills for multimedia design forced her to find another way to support her instructional activities, that is the blackboard.

Blackboard

In the teacher's classroom, the traditional blackboard remained a convenient tool in instructional activities. I observed that the highest rate of blackboard use was in the class work phase and concept implementation. The teacher explained what was for her the purpose of using the blackboard in classroom practice:

> *Blackboard writing is meant primarily to attract learners' attention. I present a thinking process to help learners understand quantity relations, step by step…using the blackboard is meant to remind learners which is the most*

important aspects of knowledge they must know. Secondly, it is to assist them to better understand for the purpose of knowledge application.

The teacher saw the blackboard as having two functions in the teaching and learning process. Firstly, it helps the teacher to highlight which aspects of the content, or which specific concepts, are important in her learners' learning. Secondly, it helps her learners to apply their new knowledge, that is, to carry out or apply procedures and skills for solving problems.

For example, in teaching and learning the concept of addition, the teacher proposed a task which used the symbolic mathematical representation of 4+4+4+4 (see Figure 4.2). Learners gave the correct answer, but when the teacher asked learners to explain their ideas of how they solved the problem, and learners could not explain their logical reasoning, the teacher used the blackboard to assist learners' concept acquisition. The teacher first wrote down the formula on the blackboard, and then asked learners to observe the whole formula. Guided by the teacher, learners identified this formula as addition. The teacher then guided her learners to conjecture how many units were in this addition, and how to solve it step-by-step. Again, guided by the teacher, learners identified a total of four units in this formula, and each unit as 4. The problem-solving method included three steps. The first step was to calculate 4+4=8. The second step was 8+4=12, and then to calculate 12+4=16.

After learners had understood, and had themselves explained the logical thinking involved, the teacher asked learners to validate their answers. At the same time, the teacher wrote down the calculation procedures which combined the presentation in a specific way. In Figure 4.2, the lines represent the calculation procedure; the answers appear under the lines. After validating the result, the teacher asked learners, based on the blackboard writing, to draw a conclusion from this addition, such as that the calculation proceeded from left to right.

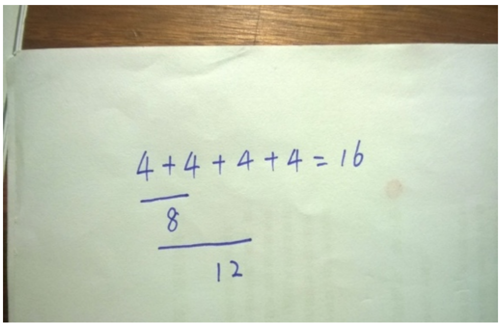


Figure 4.2. Blackboard representation of addition

It can be concluded that the blackboard both displayed and recorded the basic rule of processes and methods for learners. The learning activities divided the calculation process into the four stages of observation, conjecture, validation, and conclusion. These four processes provided clues for learners to review and streamline the learning process as well as being a deepening process for mathematical thinking. This kind of blackboard writing therefore reflects the teacher's method of teaching which focused on mathematical thinking, as well as her guidance for her learners to refine their learning methods.

From this it can be inferred that for the teacher the blackboard had value for teaching, and learning, and was suitable for helping learners recall the learning and calculation process. The blackboard writing seemed to play an important role in helping learners understand the key points of acquiring a basic mathematical thinking procedure. Therefore, from the observations it seemed that the blackboard was facilitating knowledge transmission. At the same time, the teacher's and learners' use of counting sticks seemed to further guide her learners in using them to further strengthen their concepts acquisition.

Counting Sticks

The teacher said that learning mathematical concepts through practice usually use a mathematics tools box (see Appendix 8 for tools box), and that, particularly in the case of Grade 1, they made daily use of counting sticks to assist their concept learning in a concrete way:

> *In Grade 1 level, most numeracy practice uses sticks…through sticks operation, learners can understand basic mathematical knowledge and principles, and acquire skills for numeracy; sticks operation can also help learners experience how concepts are abstract.*

In the teacher's view, particularly at Grade 1 level learners' learning should be through concrete operations whereby their learning experience moves from the concrete to the abstract; in other words she seemed to focus strongly on teaching the various mathematical concepts in an experiential way. All these learning experiences required learners to use counting sticks, an activity which enables learners to experience mathematical concepts when they are concretised through the physical counting of material objects, and hence operations can be learned through concretely experiencing their functioning.

During my observations, I witnessed learners using sticks as a tool to understand quantity relations of 100, and to establish the perception of a 10-base numeracy system. I observed that the counting sticks used in learning numbers in a specific way. Counting using sticks to build different physical formations, such as counting one-by-one to understand numbers of binding 10 of these sticks into a bundle. In this process learners acquired the mathematical experience of counting and binding as a form of representing addition and subtraction. Learning based on a bundle representing number 10 formed the basic knowledge to build a bridge to understanding the concept of addition and subtraction, such as 13 was represented in one bundle of 10, and add 3 single sticks.

In this way, learners used real material objects to represent the abstract concepts. It appeared that the sticks helped learners to establish the concept of decimal numbers as a basic tool to understand addition and subtraction. Secondly, during the operation processes, learners seemed to also complete the quantities combination, such as one bundle represents 10, and 3 bundles represent 30 (see Figure 4.3). It can therefore be concluded that operations using sticks constitute a learning path to moving from a material object to an abstract symbolic representation.

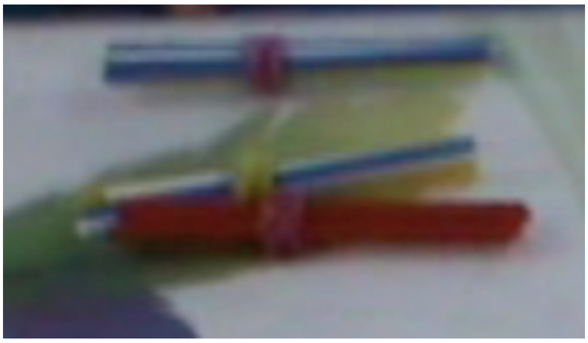


Figure 4.3. The sticks representation of 30

To sum up the teacher's observed use of teaching and learning resources: she used these with the purpose of determining whether learners had internalised, remembered, and understood the lessons presented. The teacher's use of multimedia seemed to motivate learners' interests and participation. The blackboard was used in an indirect way to highlight the mathematical thinking, and problem-solving procedure. Counting sticks were used to facilitate learners in their concrete experiencing of how concepts can be transformed from the concrete to the abstract phase, in such a way as to consolidate learners' mathematical understanding. However, in the processes of teaching and learning, the specific assessment standard influenced and led the teacher's teaching. It is a tool that the teacher used to assess learners' performance, and is discussed in full in the following section.

4.6 Assessment and Learners' Performance

This section presents the findings from document analysis conducted relating to the performance in assessment tasks of the Grade 1 learners under study. The analysis focused on what content was assessed in home work and in examination transcripts. In this section, I provide an in-depth description of assessment tasks specifically designed by the teacher to explore the forms of performance revealed in these documents, and the nature of performance in terms of interpreting the Chinese test. The findings are organized in such a way to identify, and reveal the essential characteristics of the teaching-learning activities. The document analysis explores the ways in which the teacher assessed her learners' learning, and how the nature of the assessment tasks and learners' performance reflect a form of controlled teaching.

4.6.1. The forms of assessment tasks

According to the teacher's explanation, in her view, assessments are designed to focus on two kinds of tasks: mathematical skills and mathematical principles. The acquisition of mathematical skills involves basic knowledge understanding and application, while the acquisition of a mathematical principle implies an application of basic mathematical concepts in an everyday context. Based on these two forms of assessment, learners' performance focuses more on skills of multi-methods of problem-solving, and knowledge application in the specific contexts.

Figure 4.4 and 4.5 present the nature of the two assessments tasks the teacher designed. I selected some learners' homework for analysis and comment. Figure 4.4 is typical mathematical skills task on the concept of numeracy within 20. This mathematical skills assessment was designed including eight tasks which consisted of the concepts of addition and subtraction. The concepts of addition and subtraction have been designed in the different forms.

For example, the formula of 9+( )=16 was designed as an additional form to represent the concept of subtraction. According to the different forms of concepts, learners needed to fill in the results. In order to answer this question, learners needed to understand the concepts of both addition and subtraction. The selected homework of a particular learner her/his answers were all correct, and the teacher gave her/him full marks. Similarly, prove and disprove assessment activities were evidenced in classroom activities. As discussed above in the section on the concepts consolidation phase (see 4.4.3), and the section on conceptual language teaching and learning (see 4.5.1), in the relevant lesson observed, the teacher used the counter-example method to guide learners to deduce the problem-solving procedure. The teacher used positive and counter-examples in helping learners, through two comparative examples, to acquire the concepts.

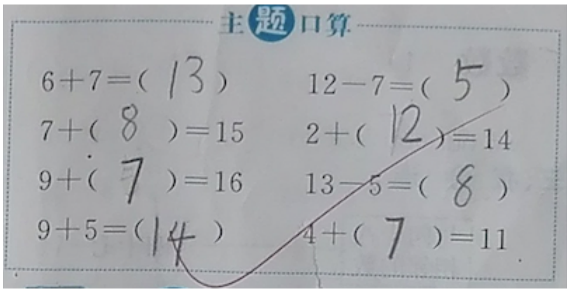


Figure 4.4. Mathematical skills task

Figure 4.5 represents a typical mathematical principle task which is about addition and subtraction applied to an everyday context, and the section of the test represented was taken from a homework task designed to consolidate and assess to what extent learners understood and could apply the concept of two-digit addition and subtraction. The task was prefaced by: "*A parents meeting includes 40 parents and 2 teachers; each person has a chair. 45 chairs are enough for all of them or not?*" The learner's performance was: "*45-42=3. Answer: Enough, there still are 3 chairs left. 45 chairs > 42 chairs*".

In order to solve a contextualised task such as this, learners first needed to understand the context described through language, and comprehend what was being asked: a problem involving the operation of addition, and relations of correspondence. Then, within this specific context, learners needed to decide which mathematical concepts could solve this problem. The first concept required to be applied to the context was to use addition to calculate the total number of people, and then to use subtraction to solve whether the 45 chairs provided for all the people were sufficient or not.

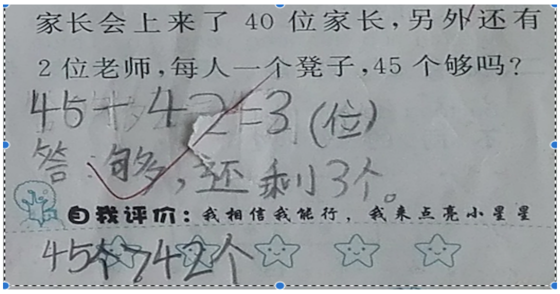


Figure 4.5. Mathematical principle task

Firstly, the learner whose homework task I was analysing wrote down the symbolic formula of 45-42=3, and wrote "enough", which implied that 45 chairs were enough for all the people. The learner expanded the answer to say that there were 3 chairs left. Secondly, the learner's performance not only indicates an understanding of the concept, but also the logical reasoning involved in solving the problem, such as 45 chairs > 42 chairs, which indicates the use of logical reasoning that 45 chairs are greater in number than 42 chairs, and thus 45 chairs are enough for 42 people. However, this learner did not write down the calculation procedure involved in calculating where 42 came from: the formula of 40+2=42 was absent. The logical reasoning was also reversed, the correct logical expression should be: 45 chairs > 42 chairs, to get to the answer: 45 chairs are enough for 42 people.

Although the specific calculation presentation of 40+2=42 was missing, the teacher still gave full marks. From this it can be concluded that the teacher's assessment focused on mathematical expression and logical reasoning rather than direct answers. This kind of assessment was also evident in classroom activities. As discussed above in the section on learner's self-learning teaching approach (see 4.3.2), the teacher focused more on encouraging learners to express their logical thinking and reasoning rather than on passive rote memory.

4.6.2 Nature of learner performance

I found some assessment tasks, specifically those set in examinations, to be different from the assessment tasks discussed above. These examination tasks were designed to gauge learners' conceptual capacity. Learners made common mistakes in mathematical knowledge application in integrating with language.

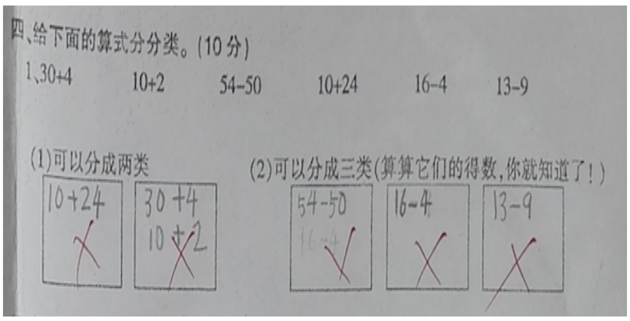
In her interview the teacher explained the difficulty of designing tasks on the difficult concept of finding laws in terms of the limited ability of Grade 1 learners to think abstractly, and that this was also a language/ literacy issues:

The mathematics content of finding the laws is hard for learners because the law itself requires higher abstract thinking, and many learners cannot understand, and many learners cannot read; so the teacher in the classroom sometimes need to act as a language teacher and teach language first on the back to teaching mathematics .

The teacher realised that the concept of finding the mathematical laws was difficult for Grade 1 learners, because this concept was designed combining the different forms of mathematical concepts, and the law itself required a higher abstract level of thinking. At the same time, at Grade 1 level, learners lacked the language ability to clearly understand and to internalise the concepts and that this needed to be integrated with language/literacy development.

In the course of document analysis, I found evidence for this in the examination transcript I selected for analysis. For example, as represented in Figure 4.6, the assessment task was "*to classify the following formulas*", and two sub-tasks were included. The first sub-task read "*Divide these formulas into two classifications*", and the second sub-task, "*Divide these formulas into three classifications*". A note was inserted alongside the second sub-task: *"Calculate them, you will know"*. The formulas were given: 30+4; 10+2; 54-50; 10+24; 16-4, and 13-9.

The teacher designed this task in order to assess the learners' ability to apply the mathematical concept which combined knowledge, thinking, and language ability. The learners were required to fill the appropriate formulas in the square under each of the two sub-tasks. Under the first sub-task of two classifications, the learner's answer was 10+24, and 30+4, 10+2. Under the second sub-task of three classifications, the learner's answer was 54-50, 16-4, and 13-9. All of these answers were marked as incorrect.


四、给下面的算式分分类。(10 分)

1、30+4　10+2　54-50　10+24　16-4　13-9

(1)可以分成两类

10+24 | 30+4 10+2

(2)可以分成三类(算算它们的得数,你就知道了!)

54-50 | 16-4 | 13-9

Figure 4.6. The task representation of finding the laws

According to this task, the law was designed based on the calculation results. Therefore, the calculation results should be 30+4=34; 10+2=12; 54-50=4; 10+24=34; 16-4=12; 13-9=4. From the results it can be seen that the law of two classifications should be two-digit and one-digit; they are 34 and 12 as a group, and 4 as another group. Correspondingly, the formulas are 30+4; 10+24; 10+2; 16-4 and 54-50, 13-9. The three classifications are 34, 12 and 4. Correspondingly, the formulas are 30+4 and 10+24; 10+2 and 16-4; 54-50 and 13-9. However, the learner's answer indicated that he was unable to find the laws required for doing this task or to fully understand what was required of him. The learner seemed to be arbitrarily filling in the formulas in each square.

The lowest scores were for tasks requiring the finding of the laws presented in this examination transcript. It can be concluded that the reason for most of the learners failing in this task was because it required them to show and use their conceptual capacity, and Grade 1 learners have not yet reached this mature conceptual capacity and/or linguistic level. Thus, most learners did not understand the task's requirements, and thus it can be inferred that one of the causes of this error was the learner's inability to understand the language used to frame the question. Therefore, the performance of most of learners showed that they did not know how to do the task, and they arbitrarily filled in equations. It can therefore be concluded that their conceptual capacity associated with their language/literacy level was still in the process of maturing, and the task required application of this capacity. At the same time, the concept of addition numbers uses is more demanding than other mathematical concepts they had been acquiring, and therefore the learners still needed to reach a higher, more mature level of conceptual development.

4.7 Conclusion

This chapter presented an analysis of the data collected from the questionnaire, interview, classroom observations, and document analysis. The chapter described the nature and content of the textbooks used for teaching number concept, and the ways in which the teacher used these, the nature of the teaching-learning activities; the various teaching and learning resources used by the teacher, and how she used them, and the nature and purpose of assessment tasks, and learners' performance in these tasks.

Also described was how, in China, the teaching and learning of mathematical concepts is required by the national education department to be based on a learner textbook and a teacher guide book, which are in turn based on the 'revised' curriculum. The content and structure of both books was described and discussed, as well as how they articulate with each other for teaching and learning in both defining the concepts to be covered and highlighting the key points of learning.

The teacher's understandings, perceptions, experiences of, and rationale for, the instructional activities she designed were described. She was observed playing a combination of the roles of controller, guide, and organiser in the process of transmitting mathematical knowledge, and guiding the development of her learners' acquisition and internalisation of mathematical concepts. The teacher's own understanding of learner-centred teaching and learning, together with the various ways in which she promoted or did not promote a learner-centred teaching approach, and how she used multi-methods of problem-solving, were described and discussed. These approaches, and the stated and possible reasons for the teacher's choice of them, are discussed further and conclusions drawn from them in Chapter 5.

Chapter 5
Discussion

5.1 Introduction

The overall aim of this study was to answer how the teacher mediated learners' acquisition of number concept in a Grade 1 classroom, and the ways in which the teacher's classroom practices were socio-culturally embedded. In this chapter, I summarise the findings and the insights obtained from the ethnographic observation of a teacher's instructional activities in a Chinese classroom context, and from her perceptions of these. The possible degree to which the cultural-historical context of classroom teaching and learning influenced the ways in which the teacher mediated knowledge and learning, and the extent to which it contributed to shaping the structure and nature of learner participation in the lessons observed is discussed.

The discussion has been informed by Vygotsky's theories of the development of scientific concepts, and posits that, despite the Chinese revised curriculum policy proposition that teaching needs to focus in a more holistic way on learner-centred activities, and on independent learning, the teacher was found essentially to control the instructional activities. The implications of these findings are that cultural influences may characterise Chinese classroom practices.

In elaborating on this dominant approach used by the teacher, I attempt to elucidate and elaborate on the socio-cultural processes that I perceived to underpin the classroom activities. Firstly, the discussion focuses on the dominance of the restricted linguistic code in the classroom under study, followed by a consideration of the nature of the content coverage, and the exam-oriented form of the teaching, and the reasons for this and the underlying reasons for the co-existence of teacher-controlled and learner-centred approaches, and the tension between the two. Then, the discussion focuses on the elucidation of the Chinese epistemic orientation as manifested in the instructional activities by means of which the number concept was mediated by the teacher, as well as a discussion of the enabling, and potentially constraining, role of the Chinese language practices for the teaching and learning of the number concept, and primary mathematics broadly. Lastly, this chapter presents a discussion on the limitations of the current study, and suggestions for further study.

5.2 Content-coverage and Exam-oriented Approach

While the teacher appeared to rely predominately on the curriculum policy to achieve the prescribed learner-centred approach, at times she re-designed and re-created what was in the learners' textbook and teacher guide book, and this seemed to focus her teaching on what she perceived would be required of her learners in the examination.

In China, the revised curriculum policy framework, in an apparent attempt to reflect a more holistic approach, does not strictly specify subject matter content and the concepts to be covered at Grade 1 level, nor the pacing and sequence of the content coverage, as is the case in South Africa. For example, the intention of this revised Chinese policy framework seems to involve a substantial shift from textbooks and the associated problems of over specification. From my observations and data analysis it appeared that the Grade 1 teacher was attempting to merge the textbook design features with her own, possibly more conservative, teaching approach derived from her many years of teaching experience.

As was described in the literature review of this study (Chapter 2), according to Vygotsky's (1978) concept of genetic law of development and activity theory (Engeström, 2001; Daniels 2016), cultural activity is a powerful lever of the educational process. Thus, based on this theory and body of research, it seemed that, in the case of the classroom and teacher observed, cultural traditions influenced her teaching in a specific way, as did culturally shaped conceptualisations her learners' concept acquisition. Therefore, the exam-oriented approach seemed to influence and constrain the ways in which the teacher's teaching could be both flexible/creative and make creative use of the textbooks as guide and a resource. In China, an exam-oriented approach seems to emphasise the passing of examinations for the purpose of progressing from lower to higher grades. Therefore, it appeared that, in order to meet the demands of the examination, the teacher, even at Grade 1 level, was in general relying rigidly on textbooks as the basic tools for designing and conducting the activities of classroom teaching and learning.

The exam-oriented approach seems to produce an ambiguous, or contradictory, yet strong relationship between the anticipated demands of the examination, the teachers' teaching, the learners' learning, and textbook usage in China. The Chinese Ministry of Education designs and specifies the national policy on classroom teaching and learning, while textbooks are usually designed by education experts within the ministry or by government, or government endorsed, publishers. However, teachers are unfortunately not normally involved in policy design processes. As a result, there seems, in many schools, to be an authoritarian structure underpinning curriculum policy, textbook production, and teachers' classroom practices. The conversation at policy development level seems to involve only specialists and textbook designers, including the government—or government endorsed—textbook designers and publishers. Therefore, it could be argued that textbooks, in spite of the revised holistic curriculum policy, in fact embody and reflect a form of authority structure informing and guiding classroom activities, and, as a result, the teachers manifest, or attempt to manifest, loyal adherence to these official knowledge documents. For example, where the teacher may consider that a specific exercise would be too conceptually or linguistically demanding for learners at a particular grade level, she may nonetheless continue to present it to, or impose it on, her learners in the manner she perceives it, through a traditional lens, as intended by the textbook.

Although curriculum policy appears to promote learner-centred teaching, the teaching approach observed in the current case study, while it appeared to be informed and guided by this approach, was simultaneously being driven by control and by certain traditional/historic authoritarian forms of classroom relations. The following section elaborates on how Chinese traditions of teaching and learning appeared to influence and shape the teaching-learning practices observed.

5.3 Epistemic Tension: Individual and Collective Approaches

As has been mentioned, the revised Chinese curriculum policy appears to promote learner-centred teaching with the purpose of ensuring all learners are able to acquire the integrant mathematical concepts and knowledge (MoE, 2011). According to the Vygotksy's (1978) concept of mediation and internalisation, the teacher's mediation role is reflected in how she uses culture as part of an activity to transmit knowledge, and how she attempts to ensures that learners through their classroom activities internalise their concept development. In the classroom teaching practices of the teacher under study, some kind of learner-centered teaching was manifested in the form of the teacher paying close attention to individual learner's responses and guiding learners through the learning processes, and her form of learner-centred approach seemed to be helping learners acquire concepts through experiencing and practicing logical thinking. For example, the teacher guided learners in exploring and discovering knowledge independently, although, at the same time, using methods to strictly monitor and control learning activities. Therefore, the dominant approach could be described as one which integrated teacher-controlled and learner-centred activity, and could also be said to relate to the Chinese epistemic approach to progressive instructional and knowledge systems as defined 25 years ago by Hedegaard (1990), and integrated into Chinese authoritarian traditions and teacher dominated, collectivist approaches.

Historically in China the people have advocated collectivism, which promotes a combination of personal and social interests, as well as taking into account the interests of the state-inclusive of the collective and the individual. Individual interests are generally subordinate to collective interests. This concept of collectivism, or collectivist ideology, appeared to continue to hold strong way in the Chinese primary classroom observed, specifically in the dominant approaches employed by the teacher to mediate mathematical concepts. Chinese education policy emphasises unified standards and a common curriculum framework. The policy framework that preceded the current revised framework emphasised equal treatment of learners, and that teachers should pay attention to the whole class in their teaching. Therefore, learners in these collectivist classrooms start learning at the same level, and teaching progresses through undifferentiated steps in order for all learners to achieve a common understanding of common subject matter content. This teaching approach used synchronization and centralization approaches to control learners' learning, so that higher achievement becomes the collective goal for both teachers and learners, with the consequence of limiting differentiation between learners. Therefore, in spite of the recent learner-centred policy provision, it appeared that collectivist ideals continued to manifest in the approach to whole-class teaching of the teacher under study, an approach which dominated her mediation of her learners' mathematical concepts, as well as her assessment strategies to gauge successful learning.

At the same time as her approach manifested this collectivist characteristic, it could be said that the teacher also focused on some form of learner-centred teaching, and provided opportunities for learners to experience and express their own ideas. Therefore, through certain interactional activities which could be described as both learner-centred, and whole class approaches, the teacher gave attention to both individuals, and to whole class collective activity. More specifically, in teaching number concept, it seemed clear that the teacher designed specific procedures to guide learning activities through control procedures in order to achieve the purpose of whole class, collective knowledge acquisition. As has been mentioned, the teacher had extensive teaching experience, and taught concepts effectively, also attempting to integrate, aspects of the learner-centred approach required by the national policy, as she perceived it, into her collectivist, authoritarian approach. However, the teacher, throughout her lessons, exercised strict control over the learning activities, often in ways that seemed to impede learners' creativity and use of their imagination in solving mathematical problems, especially where they were required to demonstrate independent knowledge under test conditions. In particular, the teacher's control manifested itself in the ways in which she used certain teaching and learning resources to facilitate learners' learning.

5.4 Use of Teaching and Learning Resources

In her classroom practices where she used teaching technology, with the exception of the blackboard, the teacher's knowledge and confidence did not seem equal to assisting or enhancing her teaching with this kind of resource. She used the blackboard confidently to facilitate concept introduction and transmission in a clear and precise manner. At the same time, she used language as a tool to clarify and mediate concept acquisition, and the modality of conceptual precision of the Mandarin seemed to be a simple and effective tool to facilitate and strengthen learners' abstractive thinking. The blackboard and language dominated the facilitation, clarity, and precision of mathematical teaching practices and activities.

5.4.1 Inadequate confidence with teaching technology

While the blackboard seemed to dominate as a teaching resource for mediating the concepts, the teacher also used concrete objects such as counters. However, what was conspicuous by its absence, was her use of information technology.

In China the rapid development of the economy, and its associated technological advances, does not seem to have resulted in dramatic changes in classroom instructional procedures. The teacher, in spite of her extensive experience and unquestionable expertise in teaching, bemoaned the lack of support she received from the school in investigating the operation and use of information technology media in classroom practices to facilitate the learning and acquisition of mathematical concepts and number operations.

5.4.2 Language vs conceptual precision

According to Vygotsky's concept of mediation, it can be argued that culturalised teaching activities could and should be used to mediate concept transmission, so that learners use psychological tools to develop their logical thinking. From my observations, and from the literature (Baroody & Ginsberg, 1990; Miller & Stigler 1987; Miller et al., 1995; 2005), it would appear that the modalities of the Mandarin facilitate concept acquisition. The teacher under study seemed to rely on, and make good use of, this linguistic structure and semiotic system to mediate concepts relating to number relations and their manipulation (Han & Ginsburg, 2001; Miller et al., 2005). However, based on Vygotsky's theory, and these studies conducted, together with my own teaching experience, I would argue that this linguistic affordance needs to be reinforced through active engagement of learners in associated activities that foster creative and innovative contributions to learning and concept acquisition.

The teacher believed that teaching should make use of conceptual language in the expression of ideas and the giving of instruction, using the formal terminology rather than, or to a greater extent than, the everyday narrative form of expressing ideas. The ZPD indicates and facilitates an on-going process of dynamic development which indicating clearly that teaching can inspire and spark learners' development (Davydov & Kerr, 1995; Miller, 2011b; Vygotsky, 1978). This, according to the teacher, enables greater precision, which in turn enables learners to be exact in working out and solving a problem, therefore affording efficiency as well as reducing possibilities for confusion. The emphasis on precise, conceptual language, and the associated mechanistic procedures that seemed to produce solution efficacy, I found to potentially result in performance difficulties at Grade 1 level. This was especially the case in an assessment situation when learners were expected to read written instructions, and use them to manipulate number operations whose solution relied on adequate understanding, and on making meaningful sense of the problem represented through linguistic expression.

5.5 Limitations of the Study and Suggestions for Further Research

The scope of the investigation was limited due to geographical, manpower and time factors, and thus the number of lessons was limited, and the sample selection was limited to one teacher and one class of learners. This study did not investigate or compare classroom instruction in different regions, and so the results may inference a limitation: they cannot be said to reflect the characteristics, overall, of Chinese Grade 1 mathematics teaching activities, nor can they be generalized to all Chinese classrooms and teachers of mathematics.

The limitations for the study, notwithstanding the relevance, and the undoubted potential that the ethnographic method has for investigating my particular research problem, and affording me an in-depth understanding of the meanings that my informant made, in terms of the teaching and learning of mathematical concepts, curtailed the duration and scope of my fieldwork. These limited opportunities to explore the extent of the complexities and contradictions involved in, or emerging from, the research topic. Wider scope may have enabled me to uncover the patterns and contradictions of the practices of mathematics teaching and learning at primary level, and their cultural underpinnings and influences. Therefore, it would be crucial for further research to investigate and take into consideration these dimensions of, and influences on, Chinese teachers' classroom practices. Such research could be designed in such a way that it could capture, not only the teachers' practices, but also the full extent of the consequences of these on, and mutual interpenetration with, learners' activities of learning and conceptual development.

Further research could also investigate in more detail the mutual embodiment of mathematical concepts prescribed by Chinese education policy for teaching and learning at primary levels with the modalities of their mediation and developmental acquisition during classroom instructional activities. This would enable deeper understanding of the cultural consistencies of these complex interpenetrating activities, as well as their consequences for learners' learning, and the developmental acquisition of the number concept in this schooling system.

5.6 Conclusion

The study is based on the idea put forward by researchers such as Wellman and Miller (1986), and Lin (2011), that formal school education plays an important role in the transformation and construction by learners of number concept. International comparison studies, such as the early studies of Miura et al. (1988), and Ho and Fuson (1998), which provided a historical perspective for understanding teaching and learning as being embedded in a particular cultural context. These studies were amongst the first to suggest that children in different countries learn differently, and thus went some way to explaining how and why Chinese learners have been achieving higher scores in international tests relative to Western learners. They, and recent studies, also suggest that one of the reasons could be that Mandarin may potentially facilitate Chinese learners' mathematical concepts acquisition (Miura et al., 1994; Miller et al., 2005).

From this point of view, Vygotsky's (1978) theory is useful as a tool for the analysis of the interaction of teaching and learning within a particular cultural context. It can provide an understanding of the link between extra cultural society, and inner mental functions. The concepts of mediation, internalisation, and the ZPD demonstrate that knowledge transformation happens in interpersonal activities, and that teaching and learning are, or can be, connected within the context of cultural-historical activities of schooling and society.

Number concept acquisition is therefore constructed through this process of cultural activities by learners' themselves. The intrinsic connection between these three concepts therefore constitutes a complete system to investigate classroom instructional activities

The practice of classroom teaching and learning of a teacher trained and experienced in culturally embedded modes of teaching reveals that the mediation of number concept, and the consequent modalities of concepts acquisition, resides to a significant extent in, and is influenced by, not only the decades long traditions of the society and schooling contexts in China, but to some extent by changes in national curriculum policy framework.

The teacher manifested strong commitment and a wealth of experience, which she used to the best of her ability to design and organise her lessons to mediate number concept to her learners. Cultural tools, such as textbooks, and spoken and written language, as well as the specific modalities of their use, were employed in unique and culturally embedded ways with mixed results in terms of learners' internalisation and application of mathematical concepts.

The finding of the study's investigation of the teacher's mediation of number concept in particular, and primary mathematics learning more broadly, reveals that the learning and acquisition of concepts is inextricably connected with the specific modalities of mediation and instructional approaches. Therefore, the general emphasis by the teacher on precision and efficacy, and on a strict control of learning, within collective society ideals that focus on the common good of all learners as a collective rather than as individuals, may explain the general success of these modes of teaching and learning within the classroom under study in terms of performance. However, the simultaneous relative lack of a truly holistic learner-centred approach that emphasises individual and independent learning and development, as well as differentiated teaching and exploratory, problem-based engagement with mathematical concepts beyond the mechanistic acquisition of skills and procedures, may impede learners' active, creative and critical engagement with concepts and with mathematical problems. I would argue that this kind of pedagogical engagement is necessary for today's rapidly changing and increasingly globalised Chinese society.

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Appendices

Appendix1: Questionnaire

1. What are the different number concept and/or mathematical concepts in Grade 1 mathematics which, according to the national curriculum policy, you are required to cover?
2. How do you teach these concepts, and how do your learners learn them?
3. What teaching-learning resources do you use to teach the concepts and subject matter content of mathematics to your learners?
4. How does the use of language for teaching, help you and your learners in the teaching and learning of mathematical concepts?
5. What specific teaching-learning activities do you think help you and your learners to succeed in the teaching and learning of mathematical concepts?
6. How do you assess the learning and successful acquisition of concepts, as well as your learners' mastery of mathematics subject matter knowledge? Why do you use these assessment methods?

Appendix 2: The interview questions

1. What is your opinion of the Grade 1 mathematics textbook? Do you find it useful in your teaching? If yes, explain how it helps or enhances your teaching, if no give reasons.
2. How do you teach and how do you try to ensure that your learners learn and are able to acquire mathematical concepts? Describe your teaching strategies and how and why you think they facilitate your learners' learning of these concepts.
3. How do you use language to help your learners learn mathematics?
4. What characteristics do you think mathematics as a subject in Grade 1 should have?
5. What teaching and learning resources do you use? Which do you find most useful and why?
6. What specific teaching-learning activities do you think could help your learners succeed in learning and in being able to acquire mathematical concepts?
7. How do you assess learners' performance? How do you know your learners are acquiring and able to apply the mathematical concepts? Why do you use these particular assessment methods? Do you think they are helpful in reviewing and /or redesigning your own teaching strategies?

Appendix 3: Teacher's information letter

University of Cape Town

School of Education

Teaching and learning of number concept in a Chinese primary classroom

Researcher: Shasha Lan

Supervisor: Dr Azwihangwisi Muthivhi

To Whom It May Concern

I am Shasha Lan, a Masters student at the University of Cape Town, interested in the study of the number concept teaching and learning in the context of China.

I would like to invite you to participate in the project that concerns the Chinese children acquisition mathematical knowledge in a Grade One class. More specifically, this study considers the relationship between culture and mathematics teaching and learning of number concept. I want to explore what activities comprise the teaching and learning of arithmetic concepts constituting the number concept. This would give some indication on the value of understanding how Chinese children in a Grade One classroom learn and acquire the number concept and how it influenced by culture.

This study requires that I observe classroom practice, interview the teacher and analysis documents (such as students' class work, homework and tests) and design relative questionnaire, and I may be taking notes during class, at times using a video camera or audio recorder for teacher participating in the study. The research will take place one week period in the second school term, in which, I intend to explore Chinese children acquisition mathematics number concept.

Please understand that participation in this study is entirely voluntary, you may decline answering particular questions or requests. However, I would be grateful if you would assist me by allowing me to observe and interview teacher using a video or audio camera; collect related documents and complete the questionnaire. All data collected in this study is considered completely confidential; the teacher's name, the students' name, the schools' name as well as anyone associated in the study will not be named in the research report, in addition, in the video images, I will not breach confidentiality by using images where the teacher is identifiable without the teacher's consent to the specific images selected, and confidentiality of participants will be guaranteed at all times, the raw data will be stored on a locked device that is only accessible to myself. There are no known or foreseen risks associated in the participation of this study.

If you have any inquiries, comments or concerns relating to your participation in this study, please do not hesitant to contact me or my supervisor on the information provided above.

Shasha Lan

Date: 13 June 2016

Appendix 4: Parents' information letter

University of Cape Town

School of Education

Teaching and learning of number concept in a Chinese primary classroom

Researcher: Shasha Lan

Supervisor: Dr Azwihangwisi Muthivhi

Greetings parents of ________[school's name]

I am conducting research towards a masters degree in Education at the University of Cape Town, interested in the study of the mathematics number concept teaching and learning in the context of China.

I would like to invite your children to participate in the project that concerns the Chinese children acquisition mathematical knowledge in a Grade One class. More specifically, this study considers the relationship between culture and mathematics teaching and learning of number concept. I want to explore what activities learning of arithmetic concepts constituting the number concept, This would give some indication on the value of understanding how Chinese children in a Grade One classroom learn and acquire the number concept and how it influenced by culture.

There will be no extra requirements of the children. They will conduct their normal school day. The only difference is that I requires to collect documents (such as students' class work, homework and tests) and I may be taking notes during class, at times using a video or audio camera for children participating in the study. The research will take place one week period in the second school term.

Please understand that participation in this study is entirely voluntary, you may decline answering particular questions or requests. However, I would be grateful If you would assist me by allowing me to collect relate documents and complete the video or audio recording. All data collected in this study is considered completely confidential; children's name, the schools' name as well as anyone associated in the study will not be named in the research report. In addition, in the video images, I will not breach confidentiality by using images where children are identifiable without parents' consent to the specific images selected, and confidentiality of participants will be guaranteed at all times. The raw data will be stored on a locked device that is only accessible to myself. There are no known or foreseen risks associated in the participation of this study.

If you have any inquiries, comments or concerns relating to your children participation in this study, please do not hesitant to contact me or my supervisor on the information provided above.

Shasha Lan

Date: 13 June 2016

Appendix 5: The consent form

UNIVERSITY OF CAPE TOWN
IYUNIVESITHI YASEKAPA • UNIVERSITEIT VAN KAAPSTAD

Faculty of Humanities

Department of Education

Name of researcher:

Shasha Lan

Title of research project:

Teaching and learning of number concept in a Chinese primary classroom

By filling out this questionnaire / answering the questions put to me:

- I agree to participate in this research project.
- I have read this consent form and the information it contains and had the opportunity to collect relative documents; observe and interview teacher as well as record classroom practice on video or audio about them.
- I agree to my responses being used for education and research on condition my privacy is respected. I understand that my responses will be used in aggregate form only, so that I will not be personally identifiable.
- I understand that I am under no obligation to take part in this project.
- I understand I have the right to withdraw from this project at any stage.
- I understand that this research might be published in a research journal or book. In the case of dissertation research, the document will be available to readers in a university library in printed form, and possibly in electronic form as well.

Name of Participant
(or Guardian if participant is under 18) : ______________________

Signature of Participant
(or Guardian if participant is under 18) : ______________________

Date : ______________________

The researcher must supply you with an ***Information sheet*** which provides his / her contact details, outlines the nature of the research and how the information will be used and explains what your participation in the research involves (e.g. how long it will take, participants' roles and rights (including the right to skip questions or withdraw without penalty at any time), any anticipated risks/benefits which may arise as a result of participating, any costs or payment involved (even if none, these should be stated))				
Has this been provided?	**Yes**		**No**	
Have your received verbal confirmation/explanations where needed?	**Yes**		**No**	

Appendix 6: The content of student textbook

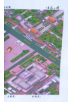
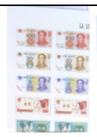
First Semester	Second Semester
Location	Understanding Graphics 2
Numeracy 1-5 and Addition and Subtraction	Abdicated subtraction within 20
Understanding Graphics 1	Classification and Organisation
Numeracy 1-10 and Addition and Subtraction	Numeracy within 100
Subtraction with borrowing and Carry adding	Understanding currency-Yuan
Numeracy 11-20	Addition and Subtraction within 100
Clock	Finding the laws
Carry adding within 20	Review

Appendix 7: The content of teacher guide book

Semester	Units	Content
First semester	Location	Up and Down; Left and Right; Front and Back
	Numeracy 1-5 and addition （subtraction）	Numeracy 1-5; Addition and Subtraction; Comparison; Ordinal; Separation and Combination
	Understanding Graphics 1	Understanding Graphics; Graphics Combination
	Numeracy 6-10 and addition （subtraction）	Numeracy 6-10 and Addition (subtraction); Numeracy Practice; Addition of Equal to 10; Subtraction of 10 minus; Number Practice.
	Subtraction with borrowing and Carry adding	Subtraction with borrowing and Carry adding; Combination of Addition and Subtraction
	Numeracy 11-20	Numeracy 11-20 and Writing; Addition and Subtraction 10 or more
	Clock	Understanding Clock
	Carry adding within 20	Carry adder within 20; Addend Position; Exchange and Constant; Practical Application.
Second Semester	Understanding Graphics 2	Understanding and Spelling Graphics; Jigsaw puzzle
	Abdicated Subtraction within 20	10 base minus 2-9; Problem Solving in Real Life; Solving the Problems of "less than more than"
	Classification and Organisation	Classification based on the different

		standards; Classification and Organisation of data tables
	Numeracy within 100	Numeracy within 100, including combination, reading, writing, ordering, comparison; Using “more or less” to descript number relation; 10 plus (minus) digit; Real Life Problem Solving
	Understanding Yuan	Understanding and Simple Calculation of Yuan
	Addition and Subtraction within 100	Addition and Subtraction based on 10; Two-digit Addition and Subtraction; Parentheses; Problem Solving.
	Finding the Laws	Graphics and Number Rules

Appendix 8: Mathematics tools box

content	Specific learning tools and learning content	Tools pictures
Location	A map (up, down, left and right)	
The abdication of subtraction	Count 20	
Graphic assembled	Cubes, triangles	 
Numeracy within 100	60 sticks; 5 roots band; figure of 10 sticks; hundreds figure of sticks.	 
Operation and thinking	Tables and figures within 100; number cards (0-20), Symbols cards (+ , -)	 
Understand Yuan	Various denominations of currency	
Addition and subtraction within 100	Sticks	
Understanding clock	Clock	
Finding the rules	Counting rings	  
Statistics	A statistics table