TEACHING VOLUME TO GRADE 7 LEARNERS IN AN INCLUSIVE CLASSROOM: AN EVALUATION OF A TEACHING APPROACH.

Zoleka Khumalo

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DECLARATION

I declare that this research report is my own unaided work. It is being submitted for the degree of Master of Education by coursework at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any university.

Zoleka Khumalo

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ABSTRACT

The study analyses and interprets effective teaching strategies that develop mathematical concepts of measurement in an inclusive classroom. In order to get a deeper understanding of these effective teaching strategies, an account of a series of lessons on volume in Grade 7 in an inclusive classroom is presented. The meanings the teacher and learners attach to the instructional situation are described and analysed. It is argued that the teacher's use of effective teaching strategies does lead to the teacher's attainment of his aims and objectives in the lessons, and to the formation of mathematical concepts by the learners in the classroom. It is suggested that the formation of mathematical concepts by learners in inclusive classrooms in general could be enhanced by the teachers' working within the learners' zones of proximal development and by employing qualitatively different scaffolds that support the learners.

DESCRIPTORS: physically disabled learners; able-bodied learners; inclusive education; scaffolding; situation definition; zone of proximal development (Z. P. D.)

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CLARIFICATION OF TERMS

Physically disabled learners refer to learners who have some kind of physical disability. As a result of their physical disabilities; some of these learners have no mobility and depend on aids such as wheelchairs, crutches, mobile cars, etc. Some learners limp as a result of their disability. Others have very weak muscles.

Able-bodied learners refer to learners who have no physical disability or any impairment.

Inclusive education can be conceived of as an education system that allows the teaching of able-bodied learners and physically disabled in the same classroom. In an inclusive approach, the curriculum, goals, methodologies are adapted by the teacher to meet the various needs of the learners in the classroom.

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CHAPTER 1

1.1 INTRODUCTION

Inclusive education, i.e. the teaching of all learners irrespective of their diversity in the same classroom, is a constitutional imperative in South Africa, and it is also a system that recognises and responds to the diverse needs of the total learner population (Engelbrecht et al, 1999). Although inclusive education is an inherent right, provided for by the constitution, its implementation is not easy because of lack of funding; under-resourced schools and large classes; lack of understanding of disability and lack of research.

Mathematics is a subject that holds high prestige in schools, the workplace and in the minds of the general public. To maintain the prestigious status, and to prepare learners for their future lives, mathematics in schools should be taught in ways that develop understanding of mathematical concepts. This can be attained through participation in meaningful activities, sharing of knowledge and discussing of mathematical ideas

Children develop mathematical concepts through active physical and mental manipulation and exploration (Myers and Hammill, 1990). In the inclusive classroom, the physical disabilities of some learners directly affect the participation in learning tasks in that these learners cannot move freely and participate actively in the class. Because of the physically disabled learners' barriers to learning, teaching mathematics in an inclusive classroom demands continuous thought and strategies from the teacher. To assist learners in overcoming barriers that might hinder their learning, the teacher's role and effective teaching strategies are crucial.

1.2 AIM AND RATIONALE

My research aims to evaluate and analyse effective teaching strategies that develop mathematical concepts of measurement in an inclusive Grade 7 classroom. In order to do this I chose to focus on one Grade 7 teacher in an inclusive school that has consistently produced outstanding results in mathematics, particularly in common examinations with neighbouring schools. I chose to focus on mathematics because it is a learning area (subject) that is viewed by the general public as "difficult". As such, few teachers are confident to teach it, and learners are prone to fail it because of it being "difficult".

The concept "inclusive" arises in the context of teaching able-bodied learners and physically disabled learners in the same classroom. Usually, inclusive education refers to a minority of physically disabled learners in a predominantly able-bodied class. The Grade 7 class in my study reverses this situation. There are a majority of physically disabled learners and a minority of able-bodied learners in this classroom. What is common to all inclusive approaches is that diversity is respected. At the school in my study, the personnel assume that the learners are intellectually competent, educable and can be expected to follow the traditional curriculum with some modification where necessary.

"The physically disabled child finds that, beside the normal anxiety of separating from his or her parents and facing the challenges brought forth by the curriculum, he or she also faces additional, unique concerns" (Bleck and Nagel 1982: 143). These concerns refer to the learners' physically disabilities and they also present their own problems. Bleck and Nagel (1982) cite that the need for repeated neurological, *urological,* and orthopaedic consultations and procedures, allowances for fairly frequent absences from school must be made. Other problems the physically disabled learners encounter mighty be a need for longer time to complete mathematical tasks. Furthermore, some physically disabled learners might need to leave the class frequently for nappy changes, medication, dressings, etc.. The implication presented by the physically disabled learners' problems is that time loss must be compensated for.

Other differences among the physically disabled learners lie with their physical disabilities: many have no mobility and depend on aids such as wheelchairs, crutches, mobile cars, etc.. Some limp as a result of their disability; some have weak arms, which make it difficult to lift learning aids such as mathematical instruments and books. The result of all these physical disabilities is diminished motor skills. It therefore implies that such physical disabilities constrain learning.

This is where the role of the teacher becomes crucial to help make the physically disabled learners' plight and experiences positive; to compensate for time loss and diminished motor skills by putting emphasis on non-motor skills and to enable effective learning that will develop mathematical concepts, by using effective teaching strategies.

As an experienced teacher in special education, especially with physically disabled learners, it has come to my attention that primary school mathematics in special schools is not receiving the attention it deserves. Instead, much focus is placed on practical subjects such as skills training. With the South African education system moving towards a policy of inclusion as reflected in the national education policy developments since 1994, all learners should be provided with opportunity to learn and develop mathematically. This includes primary school learners in inclusive classrooms.

It is against this background that I am analysing and interpreting what constitutes effective teaching strategies that develop mathematical concepts in an inclusive classroom.

In order to achieve the above aim, the following questions will be answered:

i) Does the teacher achieve his aims/objectives in teaching concepts of measurement to all learners?

ii) Which strategies enable the teacher to achieve his aims/objectives?

iii) Does the teacher use strategies for teaching measurement concepts differently with different groups of learners?

iv) What roles do the able-bodied learners and physically disabled learners play during interaction on concepts of measurement?

1.3 SIGNIFICANCE OF THE STUDY

The study is significant, as it will illuminate what constitutes effective teaching strategies that develop mathematical concepts in an inclusive classroom. It is hoped that this study could have direct benefits for teachers at the school where the study was carried out and the general teaching profession in the following ways:

- Teachers: teachers need to be equipped with skills to cater for learner diversity in teaching mathematics to enable the formation of mathematical concepts in learners.
- Inclusion: the results of this study could impact on inclusion policies.
- INSET: the findings could be an important growth opportunity for many educators when training is provided.
- Universities and colleges: these institutions could investigate the recommendations for different categories of teacher training for inclusion.

1.4 ORGANISATION OF THE RESEARCH REPORT

This report comprises of five chapters. Chapter one is the introduction and covers the aim, rationale and significance of the study. Chapter two provides a theoretical framework that helps to explore and understand effective teaching strategies in an inclusive classroom.

This theoretical framework provides the basis for understanding learning and how teaching influences learning that could enhance the construction of meaning and concept formation in mathematics. Chapter three provides the description of the methodology and the techniques used to collect data. Chapter four provides the interpretation and analysis of data that have been collected. Chapter five provides conclusions from the study and implications that the findings could have for teachers; inclusive schools; INSET facilitators and teacher training programmes for inclusion at universities and colleges.

CHAPTER 2

THEORETICAL FRAMEWORK AND REVIEW OF RELATED LITERATURE

2.1 INTRODUCTION

This chapter provides a framework for analysing effective teaching mathematics for concept formation in an inclusive classroom. Since it is crucial to understand learning in order to understand teaching, much of what is covered includes learning, the construction of meaning and concept formation in mathematics. The theoretical framework acknowledges that the learning of mathematics should centre on meaningful activity, whereby learners engage in tasks that will demand of them to communicate effectively about mathematics. Furthermore, learners should explore the meaning of concepts, and thereby form personal meanings of concepts in mathematics. In addition, the framework also acknowledges that teaching mathematics requires of the teacher to provide support so as to allow learners to construct meaning and develop concepts.

According to Vygotsky (1978) learning mathematics entails the construction of meaning and the formation of scientific concepts on the part of the learner. The process of their formation is not straightforward, but involves complex relationships between thinking, language and activity. Various processes of concept formation and the role they play in mathematics learning in an inclusive classroom will be discussed in this literature review.

Teaching mathematics for concept formation will be discussed. The discussion will centre around two constructs. The first concept is Vygotsky's concept of the "zone of proximal development" (Z.P.D.), which is a theoretical construct that describes the learning and teaching situation as comprising a unique relationship between the teacher and learner. The second concept is scaffolding, a theoretical construct that describes teaching strategies intended to assist the learner. I will draw on Vygotsky's sociocultural theory of development (Vygotsky, 1978), focusing on the Z.P.D. and scaffolding, in laying out, accounting for and explaining the effective teaching strategies in the inclusive classroom that result in the development of mathematical concepts.

The composition of a class undoubtedly influences both learning and teaching, especially of mathematics concepts. A class composed of physically disabled learners and able-bodied learners who are faced with the challenges and demands of learning mathematics concepts by, amongst other ways, being involved in practical work, definitely needs more than just "ordinary everyday" teaching methods. But the amount and kind of influence depends on the teacher's personality, his/her methods of teaching that are chosen with much precaution and the manner and extent to which learners as peers collaborate and interact with each other in the classroom. Evans (1986) cites that the attraction of Vygotsky's theory lies in the fact that it addresses constructively the educational problems posed by children with special needs by looking for solutions within the systems that support the child.

2.2 LEARNING MATHEMATICS

Learning mathematics is not a straightforward process characterised by the absorption of subject matter by the learner. Learning entails construction of meaning and formation of spontaneous and scientific concepts by the learner. Learners learn effectively through collaboration and by engaging in meaningful activities. By engaging in meaningful activities, learners benefit from the opportunity of constructing their personal meanings of the cultural meanings of mathematics. The construction of personal meanings is further enhanced by learners' use of language to communicate effectively about the mathematical concepts.

What follows is a detailed discussion of the processes that constitute the learning of mathematical concepts. These processes are the construction of meaning and the formation of concepts. I will discuss scientific and spontaneous concepts, and how these concepts interact to form true concepts. Language, activity and group-work, and the role these three aspects play in the formation of concepts will also be discussed.

2.2.1 CONSTRUCTION OF MEANING

Teaching in the instructional situation is always goal-oriented. The goal is that learners should construct meaning of concepts they encounter in the instructional situation as determined by the curriculum.

According to van Oers (1996), two types of meaning have been identified by Leont'ev (1975). These are cultural meaning and personal meaning. While being distinct, these are dependent on each other. Cultural meaning refers to "the generalised knowledge and skills dealing with the world that have been built up through cultural history. Cultural meaning can be transformed into curriculum content and, as such, it can be taught" (van Oers, 1996: 93). Therefore, in the teaching and learning situation, cultural meaning can be conceived of as the mathematics curriculum and its different topics in the form of subject matter. Such topics could include volume; integers; the use of variables; operations; number patterns; etc. that are part of the curriculum. The cultural meaning of the mathematics topics can promote cultural development in learners.

Personal meaning "is based on the attribution of personal value to the actions and goals as actually generated within an activity (in relation to some problem or task) from the perspective of one's personal activities" (van Oers, 1996: 94). Therefore, personal meaning is the sense and the understanding that learners create in relation to the subject matter (cultural meaning). In the teaching situation personal meaning refers to different experiences by each learner. For example, when learners in the same class are asked what they understood by the statement "volume is the amount of space an object occupies", different responses such as the following could be given by the different learners: "Coke in the bottle", "½ pint of milk in that cartoon", "chalk in that box", etc.. These different responses reflect the sense, understanding and the meaning that each learner attributes to the above statement in relation to the cultural meaning of volume.

Concepts cannot be assimilated by the learner in a ready-made form, but have to undergo a certain development (Vygotsky, 1992). It is therefore the teacher's task to allow learners to attach different senses and understanding (personal meaning) to the subject matter (cultural meaning) by engaging in mental activities that will lead to higher cognitive functioning. By engaging in mental activities, learners construct new meanings and knowledge; restructure and add their own findings to the existing understanding (Hatano, 1996; van Oers, 1996) and therefore participate in promoting personal and cultural meanings of mathematics.

2.2.2 CONCEPT FORMATION

Concepts are an integral part of one's cognitive structure and they are the building blocks that enable learners to think effectively.

Different authors work with different definitions of what a concept is. Hunt (1961) defines a concept as a label for a set of *percepts* which have essentially common attributes. For Korzybski (1958) concepts exist as ideas and words independently of the particular objects, events, or qualities they represent. According to Ellis (1978), a concept is "way to classify a variety of specific instances as members of a set" (p. 214). Although these definitions seem to take different forms, what is common to the different authors is that they see the learning of concepts as "achieved when a student can name and catalogue (categorise) two or more different objects, actions, or qualities into appropriate groups.

The cataloguing process is made clearer when the student can learn to use a rule to select those attributes which are essential to the concept" (Stone and Nielson, 1982: 214).

One gathers a sense of some kind of classification, of their previous experience, and the fitting of their present experiences into one of these classes (Skemp, 1971). A concept therefore requires for its formation a number of experiences which have something in common. "Whatever concept is to be learned, the learner must have a background of concrete or direct experiences to *undergird* it" (Hudgings, 1978: 112). A background of concrete or direct experience and real-life situations enables the learner to experience or extract the full meaning of a concept. "Once the concept is formed, we may (retrospectively) talk about examples of a concept" (Skemp, 1971: 97).

For example, for the concept "whale", a child must be able to recognise certain animals as whales. The child may have an image of whales as big animals that live in the sea, or even as big fish. From this knowledge, the child can generalise his/her concept "whale" through learning new facts about whales from additional examples, that is, to form new general conclusions such as that whales have blubber under their skin; that whales have fine hairs and that whales suckle their babies. In this example of learning the concept "whales", the child's spontaneous concept of whale, i.e. the recognition of certain animals as whales, for example, interacts with the scientific concept of whale. Such interaction becomes evident when the child can generate explanations about whales and realises that whales are not fish but mammals. The learner's reflection on the concept whale can be regarded as the learner's personal meaning of the cultural meaning of whales. The learning of other concepts could take the same route as the one in the example.

2.2.3 SCIENTIFIC AND SPONTANEOUS CONCEPTS

Higher psychological functions such as attention, memory and perception are reflections of control and deliberate awareness (Vygotsky, 1992). According to Zeuli (1986), Vygotsky sought to understand children's everyday (spontaneous) concepts and how these concepts became subject to their deliberate control. Vygotsky argues that spontaneous concepts are learned within a concrete situation; outside the classroom; and that these concepts are unsystematised and characterised by a lack of deliberate awareness. In operating with spontaneous concepts, the learner is not conscious of them because his/her attention is centred on the concrete object to which the concept refers: his/her attention is never on the act of thought itself. Children experience difficulties in answering questions about concepts separate from their immediate concrete experience.

Schooling, through instruction, imposes deliberate control and awareness through the development of scientific concepts. It is through instruction and schooling that scientific concepts are learned. Scientific concepts are part of the cultural meanings of a society and the idea of schooling is for these cultural meanings to become personal. Scientific concepts are used with control and deliberate awareness and can be decontextualised (they can function or can be used without the concrete objects or situations which the concepts refer to). Although spontaneous and scientific concepts are different, they are interrelated. They interact and form true concepts. Teacher-learner interaction and co-operation within the learner's zone of proximal development focuses the teacher's role on assisting the learner to understand decontextualised scientific concepts. Development and maturation of the learner's higher psychological functions are the products of this co-operation.

According to Vygotsky (1992) scientific concepts develop earlier than spontaneous concepts because scientific concepts benefit from the *systematicity* of instruction (schooling) and co-operation: "this early maturity of scientific concepts gives them the role of a *propaedeutic* guide in the development of spontaneous concepts and it is our contention that the rudiments of systematisation first enter the child's mind by way of his contact with scientific concepts and are then transferred to everyday concepts, changing their psychological structure from the top down" (Vygotsky, 1992:92). This implies that the learner's psychological structure in terms of conceptual understanding changes to true concepts as a result of the interaction of spontaneous and scientific concepts.

Zeuli (1986) points out that the development of a scientific concept usually begins with its meaningful use in non-spontaneous operation. Therefore, it is only later, in the course of schoolwork and with the teacher's assistance as the learner tries to make relations between concepts that the concepts the learners understood in outline are connected to their personal experience and everyday life-situations form the basis for making connections for meaningful learning.

For example, a learner who has learned graphs (a scientific concept) could conceptualise these as a method of representing numerical facts and thereby analysing them. He/she might find graphs useful, as he/she would be able to apply ideas learned from them in various school subjects or in his/her life, among other things. The mental activities involved in engaging with graphs require higher psychological functions (attention, memory and perception). Later, the learner can realise that he/she can use graphs to compare some facts in real-life. When the learner uses graphs in this manner, it implies that the personal meaning of graphs for the particular learner is that graphs can be used to compare information. The personal meaning for the learner could be different from other learners' personal meanings.

2.2.4 PROCESS OF CONCEPT FORMATION

There are different opinions as to what it takes a learner to learn scientific and spontaneous concepts. Piaget and Vygotsky view the learning of concepts (scientific and spontaneous) differently. Piaget does not distinguish between spontaneous concepts and scientific concepts. Piaget's theory is concerned with cognitive conflict to account for how a learner's understanding may be altered by interacting with another learner who has a different understanding of the concepts in question (Mercer, 1995). The basic idea behind Piaget's theory of cognitive conflict is that when two different views on concepts are brought together with the aim of solving a problem, the conflict is likely to stimulate cognitive restructuring, and this restructuring can result in understanding and learning of concepts.

Vygotsky theory is grounded on the fact that the learning of spontaneous concepts and scientific concepts is steered by others within one's social circumstances. According to Vygotsky (1992) the circumstances of learning scientific and spontaneous concepts are different. The learning of scientific concepts is characterised by systematicity in the classroom with the teacher and other learners; whereas spontaneous concepts are unsystematised; learned within a concrete situation; and outside the classroom. However, the learning of both scientific and spontaneous concepts is steered by other sources within the immediate environment. These sources could be the teacher and other learners in the classroom; other children or adults outside the classroom or other concrete materials.

Unlike Piaget's theory, Vygotsky's theory stresses co-operation to account for learning (Mercer, 1995). Such co-operation is characterised by collaborative learning which stimulates the understanding of scientific concepts, thereby resulting in learning: "...having to explain your ideas to someone you are learning with, whatever their relative ability, is useful because it encourages the development of a more explicit, organised "distanced," kind of understanding" (Mercer, 1995: 91). Whether one goes along with Piaget's conflict situations or Vygotsky's co-operation through collaboration for learning to occur, both theories seem to agree that interaction stimulates the learning of scientific and spontaneous concepts and the integration to form true concepts. According to Vygotsky (1992), an instructional interaction is characterised by the teacher and the learner interacting, in order for the learner to achieve internalisation (transformation onto a mental plane) of the complex cognitive "functions" that develop through interpersonal exchange and scientific concepts.

"Internalisation can be understood as a process through which *interpsychological* functioning becomes *intrapsychological*" (Pontecorvo, 1985: 15 in Bennett, 1990). This implies that by learning from others' ideas, the learner will incorporate those ideas into his/her mental plane, make them his/hers, and use them when necessary. In this way, cultural meaning becomes personal meanings. Before scientific concepts can be internalised, certain demands are made on the learner. Firstly, for scientific and spontaneous concepts to be formed, the learner has to take an active role in this concept formation. Important for learning and therefore concept formation are active engagement and commitment, not necessarily actions on things. The most genuine activity may take place in the sphere of reflection, of the most advanced abstraction, and of verbal manipulations.

Secondly, mental activity that the learner engages in, in order to form scientific and true concepts require of the learner to form personal meaning of the concepts taught to him/her. The other person (teacher or a more capable peer) will teach the concepts to the listener. It is important to note that during the teaching of concepts, such concepts are neither articulated nor distinguished as scientific or spontaneous by the person who is doing the teaching. It is the learner's understanding and experience that identifies and distinguishes the concepts as scientific, spontaneous or true. The learner who is the listener will not necessarily assimilate the concepts in a ready-made form, but will need to make personal meaning of such concepts. "Personal meaning is based on the attribution of personal value to the actions and goals as actually generated within an activity (in relation to some problem or task) from the perspective of one's personal activities" (van Oers, 1996:94). To make personal meaning will therefore require of the learner to engage in further mental activities. Such mental activities entail the construction of new meanings, knowledge restructuring and adding of the learner's own findings to the existing understanding (Hatano, 1996; van Oers, 1996). Therefore, when true concepts have been made by the learner, internalisation has occurred. According to Vygotsky (1978) the processes of internalisation and concept formation involve *mediational tools* and *signs.* These signs are chosen by the teacher specifically to act as means that make solving mathematical problems possible for the learner. These signs are "language; various systems for counting; mnemonic techniques; algebraic symbol system; writing;...[and] all sorts of conventional signs" (Wertsch, 1996:6).

A key mediational tool used in instruction at school is language. What follows is a discussion on language and activity, and the role these two tools play in the formation of concepts.

2.2.5 LANGUAGE AND CONCEPT FORMATION

Language is one means through which ideas are passed from one person to another. The unique role of language in the attainment of concepts cannot be underestimated in the instructional situation.

Mercer (1995) cites two functions of language. These are the cognitive and the communicative functions. Mercer (1995) also cites that for Vygotsky these two functions of language relate to its role as a psychological and cultural tool. It is within a culture that people communicate and thereby pass on their thoughts to other people. Theoretically, the cognitive and communicative functions are separated, but in the processes of thinking and learning they are linked. The notion of language as a psychological and a cultural tool is described by Mercer (1995) as entailing the externalisation of thoughts through talking. By talking to others, our thoughts are organised clearly and explicitly to an extent that makes them readily accessible to the listener(s). Therefore, through talking and participating in conversations, people use language as a psychological tool, which offers them the opportunity to reflect on their own thinking. Such reflection on their thinking enables the formation of concepts.

Brodie (1991) argues that oral discussion is an important part of the mathematical learning process. By engaging in discussions, learners can explain their ideas to other learners, and also get explanations from others, which will help to constitute their personal meaning. The explanations of ideas to other learners requires of them to organise their thoughts clearly and explicitly. Such organisation of thoughts stimulates a more developed understanding of the mathematical concepts to be formed.

Verbalisation plays a significant role in the meaningful use of mathematical symbols (Brodie, 1991). "While some concepts and the learning of concepts are not necessarily verbal, verbalisation makes concept learning a relative matter for learners" (Gagne, 1970: 118). During the instructional interaction, verbalisation manifests itself through the use of language and discussions. Such verbalisation is helpful to the development of mathematical concepts. Through discussions, ideas are brought forward through language, which is linked to internalisation of higher social functions (Pontecorvo, 1985).

For example, in the addition of fractions ($\frac{1}{4} + \frac{3}{4}$), learners could benefit if they listened to another learner who explained that he/she cut two oranges into quarters each. Then he took a quarter from the first orange, then three quarters from the second orange to make one orange. Engaging in such a discussion would benefit the speaker and the listeners. The speaker would have to organise his/her thoughts clearly and explicitly to allow the listeners to follow and understand his/her explanations. The listener benefits by hearing something that may enable her to restructure ideas and create meaning.

Some kind of classification of the learners' previous experience and real-life situations; the fitting of their present experience into one of the classes that have been derived through such classification; talking about examples from real-situations of concepts; etc. are some ways and means of communicating during the learning interaction and collaboration. All these ways and means of communication are necessary in the instructional interaction as "language can be used to speed up the formation of a concept by helping to collect and separate contributing examples and non-examples" (Skemp, 1971:84).

Hamachek (1979) also points out the issue of language and language differences: good teachers allow for language differences. The implication is that in multilingual classrooms the use of different languages to explain the same concept could enable the formation of a concept. However this will not be explored further in this literature review as it does not form a key focus of the study.

2.2.6 ACTIVITY AND CONCEPT FORMATION

Educationalists and teachers agree that mathematics education should not consist of attempts to "fill" learners' heads with mathematical facts such as formulae; nor should it (mathematics education) consist in merely teaching complicated and sophisticated methods of solving mathematical problems (van Oers, 1996). Instead, learners should make sense of mathematics by engaging in activities that will enable them to construct personal and cultural meanings and restructure their personal experiences into new concepts.

According to Miller (1989), activity refers to any kind of activity, i.e. mental or physical that changes the way a situation is experienced by the person who produces an action. The occurrence of an action requires a source of the action. In the teaching and learning situation the source of the action is, on one hand, the teacher. By teaching, the teacher directs learners to act in specific ways to solve problems that will result in the formation of concepts. But at the same time learners are provided with problem solving skills.

Learners in the same class can, on the other hand, serve as sources of action for their classmates. For example, when learners are engaged in group-discussions, they ask their own questions pertaining to the task and exchange views with other group members. By engaging in such activities, the learners' mental actions regulate and are also regulated by the actions of others; the learners' mental actions therefore adjust and are at the same time adjusted. By being regulated and adjusted by the actions of others, the learner in question could then begin to experience the learning situation in new ways and therefore form new concepts and new mathematical meaning of a higher order. By participating in meaningful and constructive physical activities, learners experience the opportunity of engaging in mental activities, the possibility being learning and formation of concepts. Therefore, by allowing learners to engage in physical and mental activities, teachers can give learners the opportunity to construct their own understanding, thereby creating their own personal meanings, and the cultural meanings of mathematics.

2.2.7 GROUPWORK AND THE LEARNING OF CONCEPTS

Piaget's and Vygotsky's theories differ on how concept learning occurs. Piaget's theory suggests that cognitive conflict is what it takes for concepts to be learned. Vygotsky's theory on the other hand, suggests collaborative learning as accountable for the learning of concepts. Although these theories differ on the notion of concept learning, both theories seem to agree that group-work could facilitate the learning of concepts.

Grouping learners in the mathematics classroom should be aimed at enabling learners to engage in discussions and activities that will help them develop mathematical concepts. Such discussions should be characterised by discussions on mathematical topics in which each learner participates, contributes and interacts well with other learners (Pirie, 1988). For example, for learners to understand the concepts of complementary and supplementary angles, they could engage in physical activities of constructing right angles and straight angles. Thereafter, they could bisect these angles, measure the bisected angles, and thereafter discuss what they each understand by the concepts complementary and supplementary angles. Engaging in discussions of this nature could aid the learners' understanding and correct use of mathematical terminology, an important aspect for the development of mathematical thinking (Brodie, 1991).

Pirie (1988) describes the characteristics of useful mathematical talk and discussions. Pirie's definition of mathematical talk and discussions is: purposeful talk on a mathematical subject in which there are genuine pupil contributions and interactions (p.4).

Mathematical talk and discussions should have well-defined goals set by the teacher since it is the teacher who knows quite well in advance what should be learned by the learners. These goals could then be understood and accepted by the groups so that the group-members can function and contribute positively in the discussions. Genuine learner contributions should comprise of input from at least some of the learners that generate the discussion or move the thinking forward. There should also be indications that the movement within the talk has been picked up by other participants. This may be evidenced by changes of attitudes within the group, by language (linguistic clues), or by physical reactions that show that critical listening has been taking place.

The success of learning through group-work is not spontaneous. Mercer (1995) argues that the successful pursuit of educational activity through group-work depends on learners:

a) sharing the same ideas about what is relevant to the discussion.

b) having a joint conception of what is to be achieved.

It therefore implies that the goals to be achieved must be well-defined by the teacher and learners and be understood and accepted by the learners in their respective groups.

Brodie (1991) argues that success in development of mathematical thinking in discussions is dependent on the teacher, where the teacher acts as director and mediator of discussions. The teacher should initiate discussions by providing tasks that should engage learners in conversations, which are aimed at attaining the goals set by the teacher. Mercer (1995) agrees with Brodie's (1991) notion of the teacher as director and mediator of discussion. The teacher should engage learners in activities, which are designed to encourage co-operation between learners; and such activities should also encourage a free exchange of relevant ideas and the active participation of all learners in their respective groups.

The above discussion is concerned with the important role of learning concepts through group-work by engaging learners in constructive discussions and physical and mental activities that stimulate conversation. These conversations could be stimulated by language, a key mediational tool in the instructional situation.

The discussion that follows focuses on learning volume as a mathematical topic, particularly in an inclusive classroom.

2.2.8 LEARNING VOLUME

The nature of mathematical knowledge can be viewed differently by different people. Of particular relevance is, a "growth and change" view of mathematics (Nickson; 1984:12). This view maintains that mathematical knowledge is always growing and changing, and such changes should be reflected in the mathematics curriculum. A "growth and change" view of mathematics should also be reflected in the inclusive mathematics classroom, especially in the teaching of volume. This can be achieved if able-bodied learners and physically disabled learners are encouraged to participate actively in class, engage in mathematical tasks and share knowledge with each other and the teacher.

Central to conceptual understanding of volume are certain concepts:

(i) Comparison

(ii) Conservation & transivity

(iii) Unit and measuring instruments

(iv) Volume- internal and external volume

(i) Comparison

A child's ability to measure depends on the ability to recognise similarities and differences regarding size. "Once attention is drawn to comparing size, in whatever way, then one is embarking on the realms of measurement" (Dickson et al, 1988: 7[illegible]). The suggestion put forward is that learners could be involved in discussions that involve comparing different containers, measurements of different objects, etc. By participating in discussions of this nature learners could benefit by learning from each other and thereby learn concepts of volume.

(ii) Conservation and transivity

"For Piaget, there are two fundamental operations upon which the measurement process is dependent, i.e. conservation and transivity" (Dickson et al, 1988:83). Conservation refers to the child's ability to comprehend that the quantity of an object or substance does not change even if it is transformed into a different shape. The child's ability to conserve is necessary in measurement because it captures the fact that the child can conceptualise the fixedness of quantity. In measurement of volume, the child who can conserve and understand the fixedness of a quantity can use a measuring instrument with meaning.

Transivity refers to the child's understanding of a relationship between objects. This relationship could be symbolised as: if A = B and B = C, then A = C. In the case of measurement, B represents the measuring instrument and the learner has to understand that if B gives the same measurement for A and C, then A and C have the same quantity. Therefore, conservation and transivity are necessary for all conceptual understanding of measurement, including volume.

(iii) Units and measuring instruments

In order to communicate effectively, one has to be clear about units of measurement. This clarity is crucial because it enables the listener to understand what quantity the speaker is referring to. For example, 500ml of milk refers to 2 standard cups.

One feature of the measurement process is that different units may be used to measure the same quantity. For example, 500ml = $500cm^3$. Another aspect in the development of the concept of measuring is the realisation of the relationship between the size of the unit and the number needed to measure a given quantity, i.e. the smaller the unit the more that will be required. Such a realisation requires learners to be involved in the use of concrete materials and real-life situations. For example, in measuring the volume of milk or water in a 2 litre container, the learners should realise that if they measured with a 1 litre measuring cylinder, they would transfer the liquid twice (1 litre × 2 = 2 litres); or if they used 500ml containers they would have to transfer the liquid 4 times, i.e. 500ml (cm^3) × 4 = 2 litres. This becomes important in relation to the physical nature of measuring.

Learners' ability to know the relative sizes of the units could firstly enable them to successfully predict that a quantity measured with the larger unit would measure fewer units than an equal quantity measured with the smaller unit. Secondly, it could also enable learners to think promptly whether to divide or to multiply when doing conversion from one unit to another.

Therefore, in teaching units of volume, the teacher could give learners tasks that would engage them in measuring volume of liquids by using measuring cylinders that are calibrated differently, i.e. in ml and cm^3. The teacher could even encourage learners to use ordinary containers that they use in their everyday lives. By using these containers in relation to the measuring cylinders in the classroom, learners could be able to understand the relationship between the units. On one hand, the use of this scaffold is indicative of the teacher working within the learners' zones of proximal development (see section 2.4.1). On the other hand, this scaffold could enhance the formation of concepts, and learners would then form their personal meanings in relation to the cultural meanings.

(iv) Volume - internal and external and formula

Different aspects of the concept of volume have been identified. Kerslake (1988) points out two instances of volume, i.e. internal volume and external volume. Internal volume is the same as capacity. Usually the units of measure are cubic centimetres. Litres and millimetre are also used.

External volume refers to the amount of space taken up by an object. Finding the external volume of a solid rectangular figure where only the linear dimensions are given, does not necessarily call upon the child's conceptual grasp of external or internal volume. The learner may just be applying the $L \times B \times H$ formula to display his ability to calculate. One of the major difficulties experienced by children with external volume is that they have to think of solids as made up of cubes, which cannot be seen, according to Kerslake (1988).

The discussion above focuses on those concepts that are central to learning volume with conceptual understanding. The learner's ability to measure depends on his/her ability to recognise similarities and differences regarding size. Learners' exposure to volume in everyday life was also discussed. The learners' everyday life situations could be used as a point of departure when teaching concepts of volume. Conservation and transivity are two fundamental operations which measurement is dependent upon. Units of measuring volume and use of appropriate measuring instruments of volume were discussed. Effective teaching of these could be enhanced by the teacher allowing learners to engage in meaningful activities that will enable them to construct their personal meanings, and thereby form mathematical concepts of volume.

2.2.9 SUMMARY

The foregoing discussion focused on what is entailed in learning mathematics. Theoretical constructs that explain the learning of mathematical concepts were also discussed. These constructs pertain to the construction of meaning in the formation of concepts. It was indicated that the use of appropriate language could be effective in the construction and formation of mathematical concepts when learners engage in purposeful discussions. The learning of mathematical concepts requires of the learner to play an active role in order to construct the meaning of these concepts. It was also indicated that learners could be actively engaged in physical and mental activity that could manifest during group-work, and it is during group-work that meaningful activity could enhance the construction of new meanings and the formation of mathematical concepts. Certain concepts that are central to learning and conceptual understanding of volume were discussed. What follows is a detailed discussion on inclusion, the teaching of mathematics in the inclusive classroom and how physical disabilities affect mathematics learning.

2.3 INCLUSION AND THE TEACHING OF MATHEMATICS

Mathematics is a learning area that develops important skills in learners and provides them with important opportunities in later life. Learners in the inclusive classroom should therefore be taught mathematics in a manner that develops conceptual understanding and the acquisition of skills that would create better opportunities for learners in the workplace.

2.3.1 WHAT IS INCLUSION AND ITS DERIVATION?

South Africa's moving to democracy and the respect for human rights in the last few years has led to many changes. Such changes have affected and influenced both general and special education. These changes have also resulted in the restructuring and redesigning of education, including the movement away from segregated settings for learners with special needs [1]to the provision of education for all learners in an inclusive and supportive learning environment (Engelbrecht et al, 1999). Inclusion is an education system that is responsive to the diverse needs of learners. This means that children with special needs should, wherever possible and with the appropriate support, be educated along with others..." (Donald et al 1997: 14). This approach follows similar international trends on inclusion.

[1] The writer is aware that the acronym ABLD (Addressing Barriers to Learning and Development) is the officially recommended term for learners with special needs. However, at the time of the study and at the school in which the research took place the acronym LSEN (Learners with Special Educational Needs) was preferred by the school to describe their population of children.

2.3.2 INTERNATIONAL PERSPECTIVES

International trends on inclusion have developed from attempts to found social and educational policy on principles of social justice and human rights (Donald et al, 1997 and Engelbrecht et al, 1999). Donald et al (1997) point out that in most developed countries, laws based on human rights demand that all children receive an appropriate education in the least restrictive environment that is consistent with their needs. "Only where it is absolutely necessary, in terms of a child's particular needs, should the child be educated in a context which is separate from the mainstream" (Donald et al, 1997: 14).

The 1992 "Americans with Disabilities Act" established equal rights for people with disabilities in public services and public accommodations. The trend to accommodate LSEN in the mainstream of education was highlighted by the United Nations Educational, Scientific and Cultural Organisation (UNESCO) Salamanco Statement on Principles, Policy and Practice in Special Needs Education (June, 1994). This statement was endorsed by 92 countries, including South Africa, and 25 international organisations: "schools should accommodate all children regardless of their physical, intellectual, social emotional, linguistic or other conditions" (UNESCO, 1994:9). Inclusion was advocated to combat discrimination, to achieve "education for all" and to "improve the efficiency" and "cost-effectiveness of the entire education system" (UNESCO, 1994).

2.3.3 INCLUSION AND THE SOUTH AFRICAN CONTEXT

South Africa has been slow to follow the international move towards inclusive education[2]. Major changes in policy have come about only as a result of the new democracy in South Africa. The South African Federal Council on Disability (SAFCD) (1995) and the South African Constitution (1996) called for the development of inclusive education. The SAFCD's message was clearly articulated and took the following form:

"Learners with Special Education Needs (LSEN) have a right to equal access to education at all levels in a single inclusive education system that is responsive to the diverse needs of all learners, accommodating both different styles and rates of learning, as well as different language needs in the case of deaf learners where their first language is sign language, and ensuring quality education to all through appropriate curricula, organisational arrangements, technical strategies, resource use and partnerships with their communities" (SAFCD, 1995: 1).

The SAFCD's call for a non-discriminatory type of education and therefore an inclusive education is also documented in the South Africa Constitution and is incisive:

"Every person shall have the right to basic and to equal access to educational institutions" (RSA, 1996: 16). It is against this background that inclusive education is a constitutional imperative in South Africa.

[2] The writer is aware that inclusive education in South Africa has a broader and deeper interpretation than merely the inclusion of children with some kind of inherited or acquired disorder into the regular classroom. It is the management of diversity in classrooms, which relates to issues of culture, language, race, deprivation, etc., as well as learners with "disabilities".

2.3.4 THE INCLUSIVE CLASSROOM

An inclusive classroom of learners with diverse needs makes teaching more demanding and challenging. It requires of the teacher to create an environment that is conducive to learning for all learners in the classroom. Engelbrecht et al (1999) point out that an inclusive classroom takes care of all learners; the psychosocial environment; the physical environment and the curriculum and its modification as necessary.

(i) Learners

Learner diversity is inevitable in any classroom and any teacher can expect variations in the pace and style of learning (Engelbrecht,et al; 1999). Such learner diversity is increased in an inclusive classroom. Certain learners in the inclusive classroom have special educational needs for various reasons. For example, learners who are physically disabled may require assistive devices such as computers, typewriters, etc. in order to write with such physical devices. The availability of these assistive devices could on the one hand, help the teacher to achieve specific outcomes as determined by the lesson. On the other hand, learners could also benefit by participating in written work that could also assist in the process of learning.

(ii) The psychosocial environment

An inclusive classroom needs to provide a safe and supportive environment in which all learners are willing to participate in class activities without feeling ridiculed. All learners in the inclusive classroom must feel accepted, tolerated and cared for. It is therefore the teacher's responsibility to create and maintain a classroom atmosphere that will nurture the social, personal and cognitive development of all learners in the inclusive classroom. When these aspects are nurtured, learning is enabled.

(iii) The physical environment

The physical environment of an inclusive classroom could require some alterations in order to remove barriers to learning. All barriers in the inclusive classroom need to be removed to allow accessibility to all learners. In an inclusive classroom with physically disabled learners, adequate space is needed for wheelchair access. In the same classroom, screens are needed for learners who suffer from distractibility. The desk size in an inclusive classroom with physically disabled learners is of crucial importance. Desks should be of various sizes to cater for all learners, i.e. able-bodied learners; learners on wheelchairs; learners on mobile cars; learners with crutches; learners using typewriters and computers; etc.. When the physical environment in the inclusive classroom is appropriate, teaching and learning is possible.

(iv) Curriculum

Usually learners in the inclusive classroom are expected to follow the traditional curriculum with modification where necessary. Since teachers are the people who steer the learning process, their methodology in the inclusive classroom is of crucial importance.

Inclusive teaching assumes that although there could be variations in the learning pace and style of learners, each learner in the inclusive classroom has the potential to learn. Based on this belief, the teacher's use of effective teaching strategies; the provision of opportunities for learning to take place through several modalities and the implementation of teaching methodology that will be responsive to all learners in the inclusive classroom is of crucial importance. Thus, while the concepts and the outcomes of the curriculum remain the same, ways of teaching may differ. It therefore requires an incisive teacher to adjust the curriculum so that it is responsive to all learners in the inclusive classroom.

2.3.5 THE INCLUSIVE CLASSROOM AND THE TEACHING OF MATHEMATICS

Contemporary texts on primary education as well as trends in special educational needs disfavour the view that the teacher is responsible for providing a total educational experience for all learners in his/her charge, (McClelland, 1983 in Conner and Lofthouse, 1990). The suggestion put forward by this statement is that each learner is responsible for his/her learning, i.e. each learner should take charge and control of his/her learning with help from the teacher where necessary.

The notion of learners' responsibility does not overlook the fact that all learners in the inclusive classroom come from different backgrounds and they also have different experiences. All learners in the inclusive classroom are "special" because of the different experiences, abilities, disabilities, and limitations put forward by their circumstances. But, what is common in all these learners is that they can learn and they do this in the same classroom. Also many learners in the inclusive classroom follow the regular curriculum with little modification and so learning in this particular classroom could also occur in similar ways as in other regular classrooms. The focus is placed on the teacher whose teaching should be structured so that it allows all learners in the inclusive classroom to construct and form mathematical concepts by learning meaningfully. Vygotsky argues that meaningful learning is the result of "learning with some help" and that "the limits of a person's learning or problem-solving ability can be expanded if another person provides the right kind of cognitive support (Mercer, 1995: 72).

Vygotsky's argument is relevant to inclusive classrooms in that the notion of the Z. P. D. allows for the development of all learners, including the disabled learners. Teachers can structure their teaching so that all learners in the inclusive classroom are supported to learn mathematical concepts meaningfully. Learners in the inclusive classroom could also play an important role in assisting each other to learn.

Teaching and learning cannot be separated from each other because what is learned depends on how it is taught. Therefore, the mathematical concepts learned by learners in the inclusive classroom depend on how the teacher teaches these, and on the active role each learner plays in learning the mathematical concepts. Therefore, teaching mathematics in an inclusive classroom demands on the one the hand, continued thought and ingenuity by the teacher to ensure that each learner's mathematical needs are provided for by appropriate adaptations to the curriculum and methodology. On the other hand, the different learners should be helped by the teacher to cope with any limitations imposed by their disabilities, and they should also be provided with the best opportunity for fully realising their mathematical potential. Since teachers are the people who steer the process of learning, their attitudes, beliefs and feelings about the individual learners in an inclusive classroom are of crucial importance. Gardener (1983, in Engelbrecht et al, 1999) argues that the teacher should provide a learning environment that fosters the opportunity for learning to take place through several modalities (p. 70). Such a learning environment could enable learners in the inclusive classroom to learn mathematical concepts meaningfully. Such modalities include the use of appropriate language and effective communication; and the provision of resources such as concrete, tactile, and visual learning aids that can be manipulated easily and manageably by all learners in the inclusive classroom.

An inclusive classroom raises additional issues about the methodology and the manner of interaction between the learners themselves and the teacher. The classroom needs to provide a safe and supportive atmosphere where all learners (able-bodied and physically disabled) are prepared to take risks and learn from their own mistakes without being reprimanded or ridiculed. Therefore, the teacher has the responsibility of creating and maintaining a classroom that nurtures the personal and cognitive development of all learners so as to assist each learner to form mathematical concepts. The creation of a conducive classroom in order to enhance the learning of mathematical concepts suggests the use of qualitatively different and effective teaching strategies by the teacher as well as collaboration among learners.

It was mentioned previously that learning of mathematics requires effective communication effected by language and meaningful activity that will facilitate the construction of personal meaning and thereby the formation of mathematical concepts. Teaching mathematics in an inclusive classroom should also adhere to this process of making mathematical concept learning possible. In addition, each learner's mathematical needs should be provided for. The provision of these learners' mathematical needs should be concerned with how learning of concepts takes place, on the one hand. On the other hand, the teacher's use of effective teaching strategies is of crucial importance.

2.3.6 PHYSICAL DISABILITIES IN THE INCLUSIVE CLASSROOM AND MATHEMATICS LEARNING

Good teachers do not only know their subject areas, but they also know their learners. Most importantly in the inclusive classroom, the teacher has to assess how far the nature of a physical disability affects a child's learning because much of our everyday knowledge is learned directly from our environment, and the concepts involved in mathematics can be very abstract. For the physically disabled learner in the inclusive classroom, learning from the environment might have been hindered by the learner's physical disability and the learner may therefore lack some everyday experience and the consequence could be lack of knowledge. This lack of physical experience and knowledge might be a drawback for the learner because the "disability may have restricted the opportunity for learning through incidental experiences, for the immediate environment and for becoming aware of the wider social one" (Gulliford, 1982: 170). "In mathematics, however, not only are the concepts far more abstract than those of everyday life, but the direction of learning is for the most part in the direction of still greater abstraction. The communication of mathematical concepts is therefore much more difficult, on the part of both the teacher and the learner. This makes the learning of mathematics,..., very dependent on good teaching" (Skemp, 1971: 80).

Good and effective teaching therefore relies on the teacher perceiving problems experienced by the learners as real and providing resources to overcome these problems (Hamachek, 1979). With some learners in the inclusive classroom, involvement of the hands directly affects the performance of learning tasks, and in some cases special apparatus need to be made or provided. The provision of resources requires of the teacher to bring into the classroom all those resources that are believed to be important to contribute to the learning of both the able-bodied learners and physically disabled learners. These resources include concrete, tactile and visual learning aids that are relevant to the topic dealt with and which can be manipulated and handled easily by all learners. They also include human resources and teaching strategies. These human resources are the learners - both able-bodied learners and physically disabled learners whose role is important in the classroom.

The attainment of mathematical concepts is not an easy task for physically disabled learners in the inclusive classroom. This is so because the understanding of most mathematical concepts requires of learners to have some experience of everyday life and the manipulation of concrete learning aids. This is usually not the case with physically disabled learners because of the limitations put forward by their disabilities.

Learners usually show the results of concept attainment when they read with meaning, describe situations mathematically, understand and use the symbols and vocabulary of science and other subjects in relation to mathematics. Of course, these are the skills of attainment of concept formation in any mathematics classroom, but the attainment of these is more demanding of physically disabled learners in the inclusive classroom as these are only attained by more effort from both the teacher and learners. This is important when one considers the nature of physical tasks the physically disabled learners are unable to participate in and the lack of everyday life experiences, in order to attain such skills. In measurement, particularly of volume, the attainment of mathematical concepts could be reflected in the learners' ability to understand that some units (ml and cm^3) can be used interchangeably to indicate the learners' understanding of inside volume, to associate units of measurement with the quantity that is being measured to reflect the learners' ability to communicate effectively.

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2.3.7 CONCLUSION

The foregoing discussion focused on inclusion and its derivation. It was mentioned that inclusion is a constitutional right stipulating the provision of education for all learners in supportive learning environments. Underpinning the South African and international move towards inclusion is a widespread reconstruction of respect for human rights. It was mentioned that the inclusive classroom made up of learners with diverse needs requires of the teacher to modify the regular curriculum and use teaching strategies that will suit the diverse learner population. The discussion on the inclusive classroom and the teaching of mathematics captured the notion that meaningful learning is the result of learning with some help; the limits of a learner's learning or problem-solving ability can be expanded if another person provides the right kind of cognitive support. The implication of this notion is that the teacher should structure his/her teaching so as to reach all learners in the inclusive classroom to enable them to learn mathematical concepts meaningfully. It was also discussed that besides knowing their subject areas, teachers in the inclusive classroom should also know their learners. This is so because the teacher in the inclusive classroom needs to assess how far the nature of a physical disability has affected a learner's learning, and how much drawback the physical disability has caused on the learner in terms of physical experience and knowledge.

In the next section I will deal in more detail with theoretical constructs that describe teaching mathematics in an inclusive classroom.

2.4. TEACHING MATHEMATICS FOR CONCEPT FORMATION

The aim of this section is to give a theoretical outline of what constitutes the teaching of mathematics for the formation concepts in inclusive classrooms. I intend to draw on Vygotsky's sociocultural theory of development (Vygotsky, 1978), by focusing on the zone of proximal development (Z.P.D.). The Z.P.D. will further be extended and elucidated by the inclusion of the theoretical constructs of *situation definition, intersubjectivity* (Wertsch: 1984) and *scaffolding* (Wood et al; 1976).

2.4.1 VYGOTSKY'S ZONE OF PROXIMAL DEVELOPMENT (Z.P.D.): A BASIS FOR INSTRUCTION (TEACHING).

Vygotsky's *zone of proximal development* is a theoretical construct that describes instructional interactions. The zone of proximal development describes the learning and teaching situation as comprising a negotiating relationship between the teacher and learner, and is defined as:

"the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under guidance or in collaboration with more capable peers" (Vygotsky, 1978: 86).

The Z.P.D. therefore provides us with a conceptual tool with which to try to understand the constructive processes that generate the development of mathematical concepts in the learner. The use of the zone of proximal development is relevant for teaching since, in interaction with adults or peers, learners can be assisted to operate beyond their actual level of performance, instruction (teaching) contributing to the creation of a "new zone" of proximal development. The potential level of development can be expanded according to the type and quality of the relationship and interaction that exists in the teaching-learning interaction. Most importantly, it is the teacher, who is the forerunner of actions and activities that (should) develop mathematical concepts in the instructional interaction.

Central to the Z.P.D. are Wertsch's (1984) concepts of *situation definition* and *intersubjectivity*. These concepts are useful as they elaborate the meaning of the Z.P.D. and provide us with a better understanding of the instructional interaction. Wertsch (1984) defines situation definition as:

"the way in which a setting or context is represented - that is, defined by those who are operating in that setting. I use the term definition because I want to emphasise that humans actively create a representation of a situation, they are not passive recipients of this representation. The notion of a situation definition is needed in any complete account of the Z. P. D. in representing objects and events in one way and the child's representing them in another" (Wertsch, 1984:8).

In the Z.P.D., it is possible to establish a link between the teacher and the learner in the instructional interaction so that their interaction is meaningful for both of them and for forming a basis for communication. The possibility of a shared understanding of a task depends on the "situation definition", that is, the way in which a setting or context is represented by those who are operating in that setting (Wertsch, 1984). This design of the situation is actively constructed by learner and teacher, and then becomes different for each of them: the learner's situation definition corresponds to his/her actual level of development and comes out of his/her personal meanings.

The teacher chooses a situation definition midway between his actual situation definition and the learner's. The aim of teaching (instruction) is not necessarily to bridge the gap between the teacher and learner completely, but to reach a shared redefinition of the situation, through different levels of more or less complete intersubjectivity. "The adult and child can negotiate an intersubjective situation definition that differs from both of their ways of understanding the situation of the intrapsychological plane" (Wertsch, 1984: 14). The negotiation of intersubjectivity places demands on the teacher. It has been pointed out earlier that the learner's situation definition corresponds to his/her actual level of development. With this in mind, the teacher should therefore understand the learner's situation definition; realise that the learner's situation definition is different from the "expected" situation definition and therefore be able to alter his/her (teacher's) situation definition so that it matches the learner's.

Working within the able-bodied learners' and the physically disabled learners' zone of proximal development in the inclusive classroom would then imply that the teacher's methodology and curriculum should be adapted so that each learner's mathematical needs are provided for on the one hand. On the other hand, the teacher should negotiate intersubjectivity with the able-bodied learners and physically disabled learners so that there is a shared redefinition of the teaching and learning situation. And it is in this applied procedure of intersubjectivity that the notion of *scaffolding* was introduced and devised by

Wood, Bruner and Ross (1976) as a necessary complementary process in realising the full potential of the notion of a Z.P.D. as a psychological tool effecting cognitive development.

2.4.2 SCAFFOLDING: PROVIDING SUPPORT TO LEARNERS

Scaffolding is a theoretical construct that describes a dynamic interaction between the teacher and learner as characterised by intentional supportive activity by the teacher. Central to scaffolding are procedures and strategies of the teacher in supporting the learner. Scaffolding consists of the adult controlling those elements of the task that are initially beyond the learner's capacity (Pontecorvo, 1985).

Wood (1991) cites that scaffolding entails holding the task difficulty constant, while simplifying the learner's role as much as necessary for it to be manageable by the learner. This does not suggest simplifying the task. It implies that the teacher utilises any strategy and action that in his/her opinion are supportive to the learner. Many of the strategies and actions of the teacher in assisting the learner are qualitatively different from one another. For example, the teacher could highlight crucial features of the task that have been ignored or forgotten; act as an external source of memory and planning for the learner by prompting recall of a previous activity; or help the learner to analyse the task (Wood, 1991). The intention for using these qualitative strategies is to "augment the learner's limited cognitive resources, enabling the learner to concentrate upon and master manageable aspects of the task" (Wood, 1991: 88).

Scaffolding also allows for sensitive diagnosis of the learner's intellectual needs so that these can be accommodated and catered for by the teacher. Through scaffolding, learners are assisted to form concepts and internalise these in a graduated manner. The teacher employs "hints and prompts" and shapes tasks in a flexible way so as to make adjustments for perceived requirements of the learner (Zeuli, 1986).

The abstract nature of mathematical concepts and how these will be communicated to the learners, and how learners will comprehend these will therefore depend on the teacher's scaffolding. The significant role of scaffolding by the use of appropriate language and effective communication need to be highlighted. Through scaffolding, aspects of the Z.P.D. are incorporated into the instructional interaction through language. Mercer (1995) points out that language serves cognitive and communicative functions. By this, he means that through language people communicate and thereby pass on their thoughts to other people. On the same note the teacher can use appropriate language to enhance the learners' understanding of the mathematical concepts. This is also true for learners in the inclusive classroom: by engaging in discussions about relevant and specified mathematical topics, learners can explain their ideas to other learners, and also get the opportunity of getting explanations from others which could help to form their personal meaning (Brodie, 1991). The idea of learners engaging in discussions by communicating with each other about relevant mathematical topics is in agreement with Pontecorvo's, (1985) notion of verbalisation through language, which is linked to internalisation of higher social functions.

It is therefore important for the teacher to use appropriate language to scaffold effectively during the instructional situation. The use of appropriate language as a scaffold could then enable the teacher to communicate effectively with learners to enhance the understanding of mathematical concepts.

2.4.3 SUMMARY OF THE THEORETICAL FRAMEWORK AND THE LITERATURE

This chapter provides a framework for analysing effective teaching strategies in an inclusive mathematics classroom. Understanding teaching presupposes understanding learning and the processes that learning entails. These processes involve the construction of meaning and the formation of concepts by the learner. In learning, spontaneous and scientific concepts interact and form true concepts. The formation of true concepts can be facilitated by the use of language and effective communication, and the learner's participation in meaningful activities. The formation of true concepts suggests internalisation in the learner when he/she makes personal meanings of the cultural meanings; and when he/she can reflect on the concepts by being able to generalise these concepts. Effective teaching should centre on the teacher's use of different strategies that could enhance the formation of mathematical concepts and the construction of meaning. Scaffolding, the provision of intentional and temporary support to the learner was discussed, as bringing together a range of effective teaching strategies that could enhance the formation of mathematical concepts.

Group-work and how it enhances learning was also discussed. It was mentioned that collaborative learning in group-work enhances the understanding of mathematical concepts. Learning is enhanced by group-work when learners engage in discussions that are characterised by mathematical talk on mathematical topics, and where each learner contributes to the discussions. Participating in discussions and meaningful activities in their groups offer learners the opportunity of reflecting on their own thinking, thereby forming their personal meanings in relation to cultural meanings. Such reflection enables the formation of concepts.

The discussion on teaching and learning mathematics in an inclusive classroom argued for the teacher providing for each learner's mathematical needs by providing appropriate curriculum and methodological adaptations. The teacher's provision of effective resources was discussed. These resources which serve as mediational tools include peers, concrete, tactile and visual learning aids. In the next chapter I will discuss the research methodology that was used in the study to analyse and evaluate the teaching-learning situation in the Grade 7 class.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 METHODOLOGY

The aim of this study is to analyse and evaluate a teaching approach for Grade 7 learners in an inclusive classroom. The selected methodology is an observational case study, which provides for a qualitative and interpretative analysis of the classroom-teaching situation.

Borg and Gall (1983) point out the following characteristics of an observational case study:

a) There is a particular place in the organisation.

b) There is a specific group of people.

c) Some activity by the group is evident.

This study is in line with the above-stated characteristics of an observational case study. The particular place in which this study is conducted is the Grade 7 inclusive classroom. The mathematics teacher and the Grade 7 learners are the specific group of people whose actions are observed and analysed.

What follows is an in depth discussion of qualitative research as this study, a case study, is based on qualitative research.

Ary et al (1990) argue that qualitative research is based on the notion that human behaviour is always bound to the context in which it occurs; that social reality (for example, cultures, institutions, cultural objects, etc.) cannot be reduced to variables in the same manner as physical reality and that what is important in the social disciplines is understanding and portraying the meaning that is constructed by the participants involved in particular social settings or events. It therefore implies that qualitative research seeks to understand human and social behaviour as it is lived by participants in a particular social setting (for example, a culture, school, community, etc.). Ary et al (1990) point out some aspects of qualitative research, and these aspects are concern for context; natural setting; human instrument; establishing trustworthiness; inductive analysis and reporting. My study is in line with these aspects of qualitative research and these are discussed below.

Concern for context

"Qualitative research assumes that human behaviour is context-bound, that is, human experience takes its meaning from and therefore is inseparable from social, historical, political and cultural influences" (Ary; Jacobs and Razavieh; 1990: 447). The context of my study is the Grade 7 classroom in an inclusive school.

Natural setting

Ary et al (1990) point out that the context in which human experience is studied must be naturally occurring in settings as they are found. The Grade 7 classroom and the interactions in this classroom are naturally occurring

Human instrument

Ary et al (1990) point out that in qualitative research the researcher is the data-gathering instrument. Such data is collected through observations, reading the participants' documents and written records, and recording this information. I collected the data for my study through interviews, classroom observation and tests. The interviews and classroom observation were recorded in schedules that were prepared before hand

Establishing trustworthiness

To establish the trustworthiness of the data in qualitative research one needs to employ a variety of procedures. Triangulation, the use of multiple research methods is a technique that is used to establish that interpretations and analysis are credible (Ary et al, 1990). In my study triangulation was achieved by conducting interviews, classroom observation and analysing pre-test and post-test results of the level of mathematical attainment.

Inductive analysis

Interpretation and analysis characterise qualitative research. The researcher in qualitative research reflects on the meaning of what he/she hears and sees. Ary et al (1990) point out that this process of data analysis is inductive-it proceeds from hypotheses to theory. Therefore, the analysis and interpretations of the interactions in the Grade 7 inclusive classroom will enable me to give explanations as to what constitutes effective teaching strategies in an inclusive classroom.

Reporting

Ary et al (1990) point out that reports of qualitative research are generally heavily narrative in form and contain thick descriptions of setting and context. This fact is confirmed in Chapter 4 of my study. Although some quantitative measures such as average scores and the t-test were used in this study, these assisted to interpret and analyse the test results in order to establish the effect of the teacher's intervention.

3.2 SAMPLE AND SAMPLING TECHNIQUES

The school in which the study is conducted is located in Primrose, Germiston. The medium of instruction in the school, and in the classroom in the study, is English. This school was initially a school for physically disabled learners only. Recently, however able-bodied learners have been admitted and the school has adopted an inclusive approach. This is the reverse of what is usually considered to be an inclusive approach but the classroom in the study is still appropriate. The school was selected because it is the school where I teach and is a relatively well functioning, well-resourced school with an inclusive policy.

This study uses purposeful sampling. "In purposeful sampling, researchers hand-pick the cases to be included in the sample on the basis of their judgement of their typicality. In this way they build up a sample that is satisfactory to their needs" (Cohen and Manion, 1995: 89). I have chosen the school for the reasons above. My reasons for choosing the teacher are that he had proved effective in his teaching. In previous years the Grade 7 classes whom this teacher has taught, have written common examinations in mathematics with the neighbouring schools. The results have always been outstanding. Follow-ups that my school has made of our learners in secondary schools and other institutions (such as training workshops) indicate that they continue to do well. The good results that the teacher has produced inspired my interest in understanding his teaching strategies. I have also observed some previous lessons that the teacher has presented and noticed the interesting and successful manner in which the lessons have been presented.

I observed five consecutive lessons, which covered all the work on volume, and enabled me to obtain enough data to evaluate which teaching strategies proved effective. The topics that were covered in the lessons were: the notion of volume; units of volume;

volume of rectangular figures, volume of irregular objects; and volume of gases. A detailed description of these lessons is given in Chapter 4.

The class consists of twelve physically disabled learners and three able-bodied learners. There are a number of physical disabilities in the class. The following table presents these, with the ages and gender of the learners.

TABLE 1 Able-bodied Learners in Grade 7

ABLE-BODIED LEARNERS		
GENDER	**NUMBER**	**AGE**
Female	1	14
Male	2	14 & 15

TABLE 2 Physically Disabled Learners in Grade 7

PHYSICALLY DISABLED LEARNERS			
DISABILITY	**GENDER**	**NUMBER**	**AGE**
Spastic Cerebral Palsied	Female	2	14 & 15
Athetoid Cerebral Palsied	Male	1	13
Muscular Dystrophy	Male	3	12; 13 & 15
Poliomylitis	Female	2	14 & 16
	Male	2	15 & 17
Spina Bifida	Female	1	16
	Male	1	18

The age variation in the sample, especially with the physically disabled learners is the result of these learners entering school later than their counterparts, because on the one hand, their development is sometimes slower as a result of their physical disabilities. On the other hand, the physically disabled learners are sometimes hospitalised for long periods because of their disabilities. As such, they lag behind with their schooling.

Four learners were selected to be interviewed. The selection was based on gender, physical (dis)ability and their overall performance in class and in the pre-test and post-test. The selection was also on the basis of the learners' manner of participation, active involvement and the general interaction with other learners in the groups. These factors played a significant role in the learning and teaching, and these factors were the focus in establishing the effectiveness of the teacher's teaching strategies.

Two of the chosen interviewees were able-bodied, a male and a female. The other two were physically disabled, a male and a female. The interviewees' school history is also an issue in this particular class. The physically disabled learners have attended school in the same school since Grade 0. They have been taught by the same teachers who are qualified in and experienced in teaching learners with special educational needs (LSEN). They are competent and confident in speaking and learning in English. In contrast, the able-bodied learners have attended school in the rural areas where their mother-tongues (Xhosa and Zulu) are dominant. These learners are not confident and competent in English, i.e. they struggle with English. Even in Grade 7, these learners still require extra tuition in English.

3.3 TECHNIQUES FOR DATA COLLECTION

Since this study aims to describe and explain effective teaching strategies, data has been collected through classroom observations and interviews. These research methods were relevant for analysing and interpreting the meanings and actions in the class.

In addition, a pre-test and post-test of the level of mathematical attainment of the sample was undertaken. Since there are no standardised tests available for this group of learners, the tests that were used were those developed by the previous Transvaal Department of Education for mathematical attainment for Special Education learners. One limitation of the tests was that some questions were in Afrikaans. This was problematic, since Afrikaans is the learners' third language, or even fourth language in some cases. However, I was present when they wrote the tests and I translated the Afrikaans questions into English on the chalkboard.

A pre-test was administered prior to the commencement of the section on volume in order to establish a base line of mathematical attainment. The identical test was administered three weeks after completion of the teaching of volume. The results were used to determine changes in the learners' levels of understanding of the concept of volume. Accounting for the significance of the post-test results assessed the effect of teaching.

The classroom observation schedules and the interview schedules were developed from the research questions after consultation with the researcher's supervisors. The research instruments are discussed in more detail in the following section.

3.3.1 Tests of mathematical attainment (Appendices G, H and I)

The tests consist of a pre-test and a post-test which comprises of five sub-tests. The time allocated for each sub-test is 30 minutes. One mark is allocated for each correct answer.

Sub-test 1 (Number)

This test tests the learners' mathematical concept of number. The test total is 30. The questions asked are based on conservation of quantities; reversibility; relation of class (sets) and part/whole relationships. Basic mathematical vocabulary, such as pairs; even and odd numbers; digits; place value, was also asked.

Sub-test 2 (Size)

The learners' mathematical concept of size is tested by this sub-test. The test total is 27. Aspects of measurement which are tested in this test are mass, length, capacity, time, money and instruments of these measures. Learners' ability to compare, discriminate and convert the aspects of measurement is also tested.

Sub-test 3 (Operations on whole numbers)

Sub-test 3 tests the learners' understanding of numbers in context and the total is 49. Learners are presented with diagrams of familiar animals and objects such as ice-cream; apples; pears; bowls; stools and fish. Learners have to solve problems on addition subtraction, multiplication and division. This sub-test tests the learners' problem solving skills; the concepts of the reversible interaction within and between addition and subtraction. The sub-test also requires of learners to demonstrate their understanding of a number of mathematical rules and apply these. These rules are, among others, BODMAS Rule; Addition is commutative; multiplication by 0 gives 0; multiplication by 1 gives the original number; division of a number by itself gives 1; 0 added to any number gives that number as the answer; 0 subtracted from any number gives that answer; and any number subtracted from itself gives 0 as the answer.

Sub test 4 (Fractions)

This sub-test tests the learners' understanding of fractions, and the test total is 37. The questions on fractions are asked in the form of diagrams, figures, numerals (proper fractions and whole numbers) and the number line. The diagrams are presented in the form of shapes (circles, rectangles, squares and triangles); cats; eggs and oranges.

This sub-test tests the learners' concept of the relationship of those parts to the whole and the understanding of the possible division of a multiple whole into parts; the concept of the construction of parts into wholes; and the knowledge of the number operations and the language of fractions.

Sub-test 5 (Problem Solving)

The total of this sub-test is 18 and it comprises of 5 questions that are all based on one main question. It tests the learners' ability to apply mathematical knowledge of volume and capacity; fractions and the basic operations in relation to volume and capacity; and to apply their knowledge and understanding of the concept of volume and capacity in a real-life situation.

The particular real-life situation that forms the scenario in this sub-test is that of two friends who will have friends for tea and therefore have to bake pancakes and a cake. The ingredients and the specific measurements for the pancakes and the cake are listed separately.

3.3.2 Observation schedules (Appendix B)

The observation schedules consisted of categories of events and descriptions of what the teacher and the learners did during the lessons; a narrative description of the teacher-learner interaction; and how the interaction happened in the class. The categories are: groups; teacher-learner interaction; learners' activities; and task and teaching aids. These categories were chosen specifically as they would enable me to focus and thereby describe and analyse the actions that would enable me to answer the research questions.

During the classroom observations, I completed the observation schedules by recording what was happening during the teaching-learning situation, according to the structured categories in the observation schedules.

3.3.3 Interviews and interview schedules (Appendices C, D, E and F)

According to Cohen and Manion (1995) the interview may serve as the principal means of gathering information having direct bearing on the research objectives by providing access to what is "inside a person's head", [it] makes it possible to measure what a person knows, what a person likes or dislikes, and what a person thinks, i.e. the "meaning" (p. 271).

The interviews were semi-structured. This means that questions that were asked are more flexible and open to allow for individual responses. Borg and Gall (1983) and Travers (1985) argue that the researcher can probe and also bring up issues that relate to the main questions of the study. The teacher and four learners were interviewed. The interviews helped to provide explanations of what happened in the classroom, from the perspectives of the participants.

The teacher was interviewed after he had presented the five lessons on volume. The interview schedule comprised of categories that related to the research questions. These categories are: aims and objectives; groups; learners' activities; and teaching strategies. These categories were chosen because they were thought to form the basis of the teacher's effective teaching strategies. The answers relating to these categories would enable me to understand the interaction in the classroom, and therefore be able to answer the research questions. Each category contained 3 - 5 sub-questions.

The learners were interviewed after the teacher had presented the five lessons on volume. The interview questions asked how learners experienced the lessons in terms of groups; discussions; tasks; and the use of learning aids. The interviewees were identified during the classroom observations. Four learners, 2 of each gender, were interviewed. These were learners who had worked together with other learners throughout the five lessons, and they had also displayed willingness to help other learners in their respective groups. Two learners were able-bodied and the other two were physically disabled.

3.4 PERMISSION

Before I started with the research, I obtained written permission from the principal to conduct this research at the school. The mathematics teacher also gave me written permission to conduct this research in his class. I also obtained parental permission telephonically. The Grade 7 learners gave me verbal permission to be part of their class during the presentation of the lessons. The interviewees also gave me verbal permission.

The interviews were conducted after the teacher had presented all five lessons. The teacher allowed me to interview him, but refused to be videotaped or tape recorded. I assured the teacher that the information collected in the interview would be treated confidentially and that no names would be referred to.

I also interviewed four learners. Before the learners were interviewed, I put them at ease and assured them that the questions in the interviews would have no effect on their academic performance, as this was a concern from one of the interviewees.

3.5 PROCEDURES

All learners in Grade 7 were assessed on the measure of arithmetical competence before the teacher presented his first lesson on volume and three weeks after completion.

The classroom observations were done before the interviews. I did not want the teacher to know the purpose of my study because the teacher's methods, actions and behaviour might be influenced by the questions that would have been asked in the interviews. I also wanted to gain the teacher's understanding of what I had observed in the classroom.

The teacher was observed for five lessons. Each lesson lasted 60 minutes (two periods of 30 minutes each). Each lesson was described fully. A narrative description of the lessons and the observation schedules were completed as much as possible during the observations. After the five lessons, the observations were completed thoroughly with the help of the descriptions of the lessons.

3.6 PILOT STUDY

It was important that before I undertook the main study, I did a pilot study. This helped me to check that the questions for the interviews were clear and unambiguous before being used for the main study. Piloting helped to remove items that would no yield useable data, and I was also able to assess if the categories in the observation schedules were relevant. The purpose of a pilot study is to "debug" the instruments so that the subjects will not experience difficulties in completing the instruments and so that you can carry out a preliminary analysis to see whether the wording and format of questions will present any difficulties when the main data are analysed (Borg and Gall, 1983; Travers, 1985).

To pilot this study I did two classroom observations of two Geography lessons in two different grades (Grades 5 & 6). It was not possible to do two classroom observations in the same grade because each grade had been allocated only two periods per week, and I had to do the pilot study in the same week according to the time frames agreed upon by the principal and the Geography teacher. Using the main observation schedules, I wrote down the narrative description of the lessons. I then recorded all the events that took place during the lessons according to the categories in the observation schedule. The Geography teacher was interviewed after the presentation of the two lessons.

Piloting the study was helpful because I was able to determine unclear and ambiguous statements and questions, and thereby restructured these so they should not present any problems during the execution of the main study. For example, in the category "teacher/learners' interaction", one of the question was on how the teacher worked with learners' errors. During piloting I realised that "errors" was not the correct concept and changed it to "misconceptions".

3.7 DATA ANALYSIS

Initially I started with categories on observation schedules and interview schedules. But, through further analysis these categories changed. The analysis of classroom and interview data was done through the use of categories that were developed to assist in the interpretation of the interaction in the classroom. These categories are: groups; the use of simple language; the use of concrete teaching aids; the use of concrete or real-life situations and the use of examples; and scaffolding effectively. The test results were analysed statistically by a statistician using a *t*-test. The results of the analysis are presented in Chapter 4.

3.8 RELIABILITY, VALIDITY AND GENERALISABILITY

Reliability and validity stem from quantitative research methods and they pertain to the measuring instruments that are used in the research (Travers, 1985). It is important for measuring instruments to be characterised by reliability and validity so as to put faith in the results obtained and the conclusions drawn from these results. Qualitative research is characterised by describing and analysing "the sets of meanings which people use to make sense of their world and behaviour" (Cohen and Manion, 1995: 10). In this study, there is the need to understand the meanings that the teacher and learners attribute to the instructional situation. Central to qualitative research is "human - as - instrument" (Cohen and Manion, 1995: 10).

Travers (1985) and Ardy et al (1990) point out that the human person is the only instrument flexible enough to capture the complexity, subtlety and constantly changing situations, which constitute the human experience. This implies that "the researcher is the data-gathering instrument. He or she talks with people in the setting, observes their activities, ...and records this information" (Ardy et al; 1990: 447). Interpretation by the researcher is the central concern in qualitative research: interpretation of the subjective meanings which individuals place upon their actions. This study is concerned with the interpretation and analysis of the teacher's actions in the Grade 7 inclusive classroom in order to get a deeper understanding of his teaching strategies. In qualitative research, the credibility of the interpretation and analysis relies on the reliability and validity of the measuring instruments. What follows is a discussion of reliability and validity in qualitative research.

3.8.1 RELIABILITY

In qualitative research, reliability can be evaluated by the use of various research methods. One such method is triangulation (Borg and Gall, 1983; Cohen and Manion, 1995; Travers, 1986), which is applied in this study. In my research I used three methods of research: tests, classroom observations and interviews (teacher's and learners'). To evaluate the reliability of the tests, I analysed the test results by accounting for the significance of the post-test results to establish the effect of the teacher's intervention. The classroom observation and interviews were analysed and interpreted to get a deeper understanding of the interactions in the Grade 7 classroom and thus established what constitutes the teacher's effective teaching strategies. The use of these research methods and thus triangulation enabled me to establish trustworthiness of the data (Ardy et al, 1990). This permitted the analysis and explanation of the data from different perspectives, thus reducing the possibility of bias by the researcher and sample.

3.8.2 VALIDITY

In qualitative research, validity refers to the degree the researcher reflects reality as it is lived by the participants in particular social settings. Therefore the appropriateness, meaningfulness and usefulness of the inferences a researcher makes (Borg and Gall, 1983; Kerlinger, 1986, and Travers, 1985) in reference to a particular setting reflect the validity of the research methods.

The research methods, that is, pre-test and post-test, classroom observations and interviews that are used, are derived from the research questions and are therefore appropriate for this study. These research methods are concerned with a context; constrained within a natural setting; and the human instrument, the researcher (Ardy et al 1990) is enabled to explain and describe the actions of the teacher and learners in the classroom and to infer their meanings.

The appropriateness of the inferences made is further backed-up by the theoretical framework which is laid out in chapter 2. The theoretical framework constrains the interpretations that the research can make and locates them within a particular perspective.

3.8.3 GENERALISABILITY

Generalisability refers to the extent to which explanations and accounts of a particular situation can be applied to other contexts, persons or settings (Cohen and Manion, 1995; Kerlinger, 1986). Despite the fact that this study is carried out in one school with a small sample, similar conditions prevail in certain schools and other institutions. In addition, the theoretical framework in Chapter 2 locates this study within the literature. By combining the theoretical frame and the research findings, others can interpret these research findings and then transfer these into their situations. The claims may not be easily generalisable but they can resonate with and illuminate other settings.

3.9 LIMITATIONS

The study is affected by a number of issues. Firstly, the sample size is small and not adequate enough to make easily general conclusions. This sample is further affected by the small number of able-bodied learners in the class. The able-bodied learners are outnumbered by the physically disabled learners in the school as the school initially admitted only physically disabled learners and has only adopted an inclusive approach recently.

Secondly, the research methods used in the study have some limitations. It was my intention in initial planning to videotape the lessons and also tape-record the teacher's interviews. The teacher objected to both requests. As such, valuable information may have been omitted unintentionally in the narratives, descriptions of the lessons and interviews because there was no way I could have reviewed those repeatedly. It was not difficult to record the learners' interviews as their utterances and explanations were not lengthy.

Thirdly, interviewing poses some problems. Travers (1985) points out that the interviewee may not be willing to reveal information, and the researcher must draw conclusions from what happened and what the interviewee says. Borg and Gall (1983) point out that there could also be misunderstandings on the part of the respondent of what is being said. I tried not to be biased, but Cohen and Manion ?995) point out that the interviewer's attitudes and opinions might be sources of bias in the sense that "the researcher might seek answers that support her preconceived notions; misperceptions on the part of the interviewer of what the respondent is saying" (p. 272). These limitations constrain, but do not invalidate the findings of the study. There is still much to learn from the study itself. In the following chapters I will report on the data analysis and interpretation and draw out implications from these.

CHAPTER 4

DATA ANALYSIS, INTERPRETATION AND DISCUSSION.

4.1 INTRODUCTION

This chapter deals with the interpretation and analysis of data that was collected through tests, classroom observation and interviews with the teacher and learners. The test results were used to establish if there were changes in the learners' levels of understanding of the concept of volume. The classroom observation and interviews were used to obtain a deeper understanding of the interactions in the Grade 7 classroom. The interpretation and analysis of the data will provide answers to the central questions of the study. A summary of these answers will also be provided in chapter 5. The questions are:

(i) Does the teacher achieve his aims/objectives in teaching concepts of measurement to all learners?

(ii) Which strategies enable the teacher to achieve his aims/objectives?

(iii) Does the teacher use strategies for teaching measurement concepts differently with different groups of learners?

(iv) What roles do the able-bodied learners and the physically disabled learners play during interaction on concepts of measurement?

My analysis and the answers to the research questions will provide an argument that in the Grade 7 classroom the learners' physical disabilities were not a major barrier to their learning because the teacher's teaching strategies were effective in overcoming their disabilities. So, I will argue that good teaching compensates for disability in small classes.

I will first discuss the test results. The test results will indicate that the teacher's teaching strategies were more effective for the physically disabled learners than the able-bodied learners'. The test results show improvement for all learners, but the physically disabled results are statistically significant. The test results will then be followed by a brief description of the five lessons that were observed. The description of the lessons is important because it describes and illustrates how the physically disabled learners and the able-bodied learners interacted with each other during the lessons. This description also indicates and describes how the teacher worked with the different learners during the lessons.

After the description of the lessons I will then analyse the teaching in relation to a set of categories that were developed during the research. The analysis explains the contextual circumstances and the interactions that constituted the teaching-learning situation in the Grade 7 classroom.

4.2 TEST RESULTS

A detailed description of the tests is given in Chapter 3. In this section I will discuss the statistical analysis of the test results.

Three categories of results were obtained. The first category are the pre-test and post-test results of all learners in the class, the second category are results of the pre-test and post-test results of physically disabled learners, and the third category are the pre-test and post results of the able-bodied learners. These categories provided the comparison of results to determine the effect of the teacher's intervention.

The results were compared by means of t-tests of significance. The t-test compares the means of the pre-test and post-test results. If the t-value obtained is 0,05 or less than 0,05, significance can be demonstrated. This implies that the probability that the post-test results could have occurred as a result of the teacher's intervention is high. Such probability is indicated by Pro>/T/ in the Tables below. If the obtained t-value is greater than 0,05, then there is no significance in the results of the pre-test and post-results. The implication is that the probability that the improvement in the post-test results could have occurred as a result of the teacher's intervention is low, i.e. the improvement could have occurred by chance.

Th first set of test results in the table below show no significant improvement in the post-test results when the class as a whole is analysed.

TABLE 3: Pre-test and Post-test Results of Physically Disabled and Able-bodied Learners.

	Test 1 Number		Test 2 Size		Test 3 Operation on number		Test 4 Fractions		Test 5 Problem Solving	
	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post -test (%)	Pre-test (%)	Post-test (%)
Total Raw Score	**1026**	**1285**	**773**	**895,4**	**1052**	**1221**	**745**	**950**	**261**	**683**
Number of Subjects	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**	**14**
Average Score (%)	**73**	**92**	**55**	**60**	**75**	**81**	**53**	**63**	**19**	**46**
Pro>/T/	**0,0328**		**0,1735**		**0,0579**		**0,0514**		**0,3606**	
Significance	**Not significant**		**Not significant**		**Not significant**		**Not significant**		**Not significant**	

The test results indicate that there was no significance in the post-test results of the five tests. However, there was a general improvement in terms of average scores that improved by 19%; 5%; 6%; 10% and 27% respectively. The greatest improvement was in Test 5 (Problem Solving). The questions in this test were based on volume, the main focus of the study and of the teaching between the two tests. The improvement, while not significant indicates a trend towards better levels of understanding.

However, when the test results of the physically disabled learners are considered on their own, the results are significant as shown in Table 4 below.

TABLE 4: Pre-test and Post Results of Physically Disabled Learners.

	Test 1 Number		Test 2 Size		Test 3 Operation on number		Test 4 Fractions		Test 5 Problem Solving	
	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post -test (%)	Pre-test (%)	Post-test (%)
Total Raw Score	906	1054	629	747	855	1013	629	813	255	599
Number of Subjects	11	11	11	11	11	11	11	11	11	11
Average Score (%)	82	88	57	62	78	84	57	68	23	50
Pro>/T/	0,0017		0,720		0,0023		0,0001		0,0006	
Significance	Significant		Not significant		Significant		Significant		Significant	

The results indicate the physically disabled learners' post-test results had improved in the five tests. The post-test results for the five tests had improved by 6%; 5%; 6%; 11% and 27% respectively. As with the whole sample, the physically disabled learners' results improved the most in Test 5 (Problem Solving). This test assesses the learners' understanding of volume and as such was directly related to teaching volume of the study.

Levels of significance in Test 1 (Number); Test 3 (Operations on numbers); Test 4 (Fractions) and Test 5 (Problem Solving) support the probability that the improvement in post-test results occurred as a result of the teacher's intervention.

Although the sample is small, the test results of the able-bodied learners as indicated in Table 5 below were not significant. However, as in all tests the greatest improvement was in Test 5.

TABLE 5: Pre-test and Post Results of Able-bodied Learners.

	Test 1 Number		Test 2 Size		Test 3 Operation on number		Test 4 Fractions		Test 5 Problem Solving	
	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post-test (%)	Pre-test (%)	Post -test (%)	Pre-test (%)	Post-test (%)
Total Raw Score	213	213	144	148	198	208	116	138	6	83,2
Number of Subjects	3	3	3	3	3	3	3	3	3	3
Average Score (%)	71	71	48	33	66	69	39	46	2	27
Pro>/T/	0,5799		0,4226		0,1296		0,2507		0,1074	
Significance	Not significant		Not significant		Not significant		Not significant		Not significant	

The major finding from the statistical analysis is that the improvement in the physically disabled learners' test scores is significant. Although there is no statistical significance for the able-bodied learners, the sample is small so these results may be misleading. It is interesting however to see that both groups improved most on Test 5, which is what the teaching focused on.

Thus the physically disabled learners' performance improved as a result of teaching while the able-bodied learners did not necessarily improve. In Chapter 3 it was mentioned that the physically disabled learners have attended school in the same school since Grade 0. They have been taught by the same teachers who are qualified in and experienced in teaching learners with special educational needs (LSEN). They are competent and confident in speaking and learning in English. In contrast, two able-bodied learners have attended school in rural areas where their mother-tongues (Xhosa and Zulu) are dominant. These learners are not competent in English, i.e. they struggle with English. Probably the difference in school history accounts for the difference in performance of the able-bodied learners and physically disabled learners in this inclusive classroom. The fact that the able-bodied learners' post-test results did not improve could be attributed to these learners' incompetence in English. It could also be that the able-bodied learners might not be used to learning from the kinds of strategies that the teacher uses, hence there was no improvement in their post-test results.

Having established statistically that the teacher's teaching strategies were helpful for the physically disabled learners, in the rest of this chapter I will try to provide an explanation of why this is so, through a description of the teacher's teaching strategies. First, I will provide brief descriptions of the five lessons. It will be explained how the physically disabled learners and the able-bodied learners interacted during the lessons. It will also be explained how the teacher worked with the different learners during the lessons.

4.3 DESCRIPTION OF LESSONS

Five 60-minute lessons were observed. Learners working in groups dominated the lessons and the groups remained the same through all the lessons. Direct teacher intervention was evident throughout the lessons. For example, the teacher explained concepts to the learners confident in speaking and learning in English. In contrast, two able-bodied learners have attended school in rural areas where their mother-tongues (Xhosa and Zulu) are dominant. These learners are not competent in English, i.e. they struggle with English. Probably the difference in school history accounts for the difference in performance of the able-bodied learners and physically disabled learners in this inclusive classroom. The fact that the able-bodied learners' post-test results did not improve could be attributed to these learners' incompetence in English. It could also be that the able-bodied learners might not be used to learning from the kinds of strategies that the teacher uses, hence there was no improvement in their post-test results.

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4.3 DESCRIPTION OF LESSONS

Five 60-minute lessons were observed. Learners working in groups dominated the lessons and the groups remained the same through all the lessons. Direct teacher intervention was evident throughout the lessons. For example, the teacher explained concepts to the learners by using relevant and appropriate examples; he used real-life experiences to clarify concepts; he worked on learners' misconceptions and problems. The teacher used teaching aids in all lessons, which as I will argue were appropriate for the concepts he was teaching.

The teacher and learners communicated with each other through language which, I will argue, was appropriate and understandable. However, sometimes the teacher did not notice some learners working on "wrong" tasks. The unnoticed behaviour from learners might lead to learners not learning what the teacher had intended them to learn. Although there was a small sample of able-bodied learners, these learners did not contribute much during discussions. The physically disabled learners often overpowered them during discussion. This could have led to valuable information being missed out by all learners in the groups.

During the lessons, different physically disabled learners walked out of the classroom to attend to their individual "problems" such as going to hospital; attending physiotherapy or occupational therapy; going to change nappies; etc.. The able-bodied learners accompanied some of the physically disabled learners who could not push themselves on wheelchairs. The teacher continued with teaching even though some learners had gone out of the class.

Lesson 1

This was an introductory lesson on volume. The aim of the lesson was that learners should develop understandings of the concepts of volume. The teacher introduced the lesson by referring to quantities of food and the containers that the food is bought in. This distinction was to enable learners to understand the notion of volume as "space occupied by an object" as denoted by the food rather than the containers.

The teacher engaged the learners in a "questions and answers" exchange that developed the notion of volume. During the question and answer exchange, learners were seated in rows. After this the teacher told them to sit in groups and directed them where and with whom to sit. In their groups, learners engaged in activities that involved the construction of blocks using wooden cubes and dice. Each side of these wooden cubes and dice measured 1cm. As some physically disabled learners constructed the blocks, some able-bodied learners recorded the total number of wooden cubes and dice while the rest of the learners observed. With the same number of wooden blocks and dice, learners constructed other blocks by changing the dimensions, i.e. the length, breadth and height of the blocks. The aim of this activity was to teach that the total number of the wooden cubes and dice that made up the block stayed the same even if the shape changed. The group that used dice would sometimes be distracted and concentrate on counting the dots on the dice. At first the teacher did not notice that, but later noticed what the group did. He exchanged the dice with the group that used the wooden cubes. During the activity, the teacher moved from one group to the other to observe if the learners were coping with the task. The teacher engaged the learners in discussion about the activities they had engaged in, drawing their attention to the notion of conservation.

Learners were asked to discuss in their groups what they had learned about volume, and the teacher wrote the summary of the lesson. This is what was in the summary:

(i) We can measure volume.

(ii) I can calculate volume.

(iii) Volume means the space the object occupies.

(iv) Volume does not change even if the cubes or dice could be arranged differently.

During the lesson one learner stood up and went for physiotherapy. Another learner stood up and took his medicine. The moving up and down of these learners did not disrupt the lesson. It seemed such movements are considered normal in an inclusive classroom. On one hand, the teacher did not question the learners about their moving. On the other hand, the learners did not ask permission from the teacher to go out or to take medicine. In Chapter 2, it was mentioned that an inclusive class needs to provide a safe supportive atmosphere where learners are provided for and are helped to cope with any limitations imposed by their disabilities. Therefore, the teacher provided for the learners' needs in this regard.

Lesson 2

This lesson aimed to enable learners to understand and use the formula for calculating the volume of a rectangular figure. Learners sat in their groups. These groups had not changed from the previous day.

The teacher asked the learners to measure each side of the wooden cubes and dice. Each group reported that each side measured 1 cm. The teacher asked learners what a cube is, and he asked learners to look for the meaning of cube in the dictionary. He then wrote on the chalkboard the meaning of a cube as "a solid object with six equal square sides". The learners verified that their wooden cubes and dice matched the definition.

The learners were then requested to construct a block by using 24 wooden blocks and dice. The teacher used the words "rows" and "layers" to enable learners to associate these words with breadth and height, and thereby conceptualise the breadth and height of the blocks. Learners were asked to identify the lengths of their blocks. "Length" was not substituted by any word because it had retained its meaning in relation to the side. The teacher asked the learners to "substitute rows and layers with the correct words", and learners were able to say breadth and height. The teacher then wrote: Length × Rows × Layers. Learners were then required to "substitute rows and layers with the correct words". Learners agreed in their groups that it should read: Length × Breadth × Height.

The teacher then asked the learners to construct blocks with measurements of their choice, and thereafter, use the formula in relation to the blocks in each. The learners' attention was drawn to cubic centimetres in the answer ($24cm^3$). This was done by referring to 1cm as denoted by the measurement of each side of the wooden cubes and dice; and "cube", with its meaning. That is, in $24cm^3$, there are 24 cubes that measure 1cm on each side. As learners engaged in these activities, they talked and recorded their measurements. Later, learners were asked to report to the whole class on the groups' activities. The different groups gave the following reports pertaining to the measurements:

i) W's group: $L = 4cm$; $B = 5cm$ and $H = 2cm$.

$$V = L \times B \times H$$

$$= 4cm \times 5cm \times 2cm$$

$$= 40cm^3$$

ii) S' group: $L = 4cm$; $B = 3cm$ and $H = 6cm$

$$= 4cm \times 3cm \times 6cm$$

$$= 72cm^3$$

iii) P's group: $L = 3cm$; $B = 6cm$ and $H = 2cm$

$$= 3cm \times 6cm \times 2cm$$

$$= 36cm^3$$

One learner, a muscular dystrophy sufferer and in a wheelchair asked a classmate to push him to the toilet as he was too weak to do that himself. Again, these learners did not ask for permission from the teacher and the teacher did not question the learners.

Lesson 3

This lesson was based on measuring the volume of liquids. Learners had to measure liquids and use the units ml and cm^3, understanding their relationship. In their groups learners measured 1 cup of water and poured it into a measuring cylinder calibrated in ml. After doing that learners recorded the measure. Learners were then required to transfer the water into a measuring cylinder calibrated in cm^3. The teacher asked learners what the measure was, and what the meaning of the findings was. Learners discussed in their groups and answered that the meaning is that 250ml = 250 cm^3, and therefore ml = cm^3. With the use of the measuring cylinders calibrated in ml and cm^3, learners were allowed to explore the notion of millilitres and cubic centimetres. During the activities, they engaged in discussions pertaining to the tasks.

During the lesson, the occupational therapist came in to put a ribbon into one of the learner's typewriters. One learner followed the occupational therapist and went for therapy.

Lesson 4

This lesson was based on the measurement of irregular solid objects. Learners had to understand that there is no length, breadth, or height in irregular solid objects. But the volume of these objects can still be measured. The teacher asked the learners how they thought the volume of a stone, for example, could be measured. One physically disabled learner said it could not be measured since a stone did not have "length, breadth and layers", (i.e. height). The teacher then told them that there was an alternative method of measuring the volume of a stone, or any figure that did not have the three sides.

The learners engaged in an activity that required them to immerse an irregular object into a measuring cylinder. Learners had to take readings of the water level before and after they immersed the object. The teacher allowed the learners to discuss the meaning and the implications of the two readings. The teacher and learners engaged in the discussion of the activity. Learners then calculated the difference in the readings. The teacher then explained the concept of displacement of a liquid. Learners gave their own examples of displacement in their everyday life, for example, e.g., cooking pap; taking a bath; making tea and so forth.

Two physically disabled learners left for hospital because they had appointments with the orthopaedist at the local hospital.

Lesson 5

This lesson was about measuring the volume of a gas. Learners were asked if gases could occupy space. Learners answered by saying yes and gave examples of instances were gases occupy space: "Easigas"; "In a balloon"; "I mean a tyre". The teacher affirmed the learners' answers, but cautioned them that it was not very easy to measure the volume of gases in everyday life.

The able-bodied learners distributed equipment for doing an experiment on measuring the volume of air and handed out worksheets pertaining to the same experiment. For the experiment, the able-bodied and the physically disabled learners inflated balloons and half-tied these so that the air could not escape. Thereafter, they inserted syringes into the balloons while untying the balloons slowly. At the same time, one learner in each group pressed the balloon gently so that it released the air into the syringes by pushing the plunger. Learners discussed the experiment by referring to issues such as why the plungers had moved; by "how much the plunger had moved" and what the meaning was of the quantities that the plungers had moved by was.

As learners engaged in this activity, the teacher moved from one group to another to see if learners followed the instructions on the worksheet. It seemed that learners struggled to perform the experiment even though they understood the instructions on the worksheets. The balloons could not be deflated easily so that they pushed the plunger to indicate the volume of air that was in the syringes. The plungers seemed too tight, and they could not easily move as the balloons were deflated. Learners recorded their findings after they had struggled a lot with the experiment. The teacher discussed the experiment with the whole class and explained what the outcome of the experiment should have been. The teacher acknowledged to the learners that the experiment was not easy, and that he wanted them to perform the experiment to give them an idea of how the volume of gases could be measured.

Two physically disabled learners who had been hospitalised the previous weeks went for physiotherapy to put on splints. Another physically disabled learner went out to have the tyre of her wheelchair pumped.

4.4 ANALYSIS OF TEACHING STRATEGIES

Vygotsky's sociocultural theory describes the teaching and learning situation as composed of a negotiated relationship between the teacher and the learner. Instructional negotiations occur in the zone of proximal development, which is defined as:

> "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under guidance or in collaboration with more capable peers" (Vygotsky, 1978: 86).

The teacher in my study employed a range of strategies that enabled him to create and work in the zones of proximal development of the learners. Therefore Vygotsky's theory provides a useful theoretical framework to analyse the data. The analysis and interpretation of data will be discussed under the five categories that will be related to the theoretical framework in Chapter 2. These categories are:

(i) Groups

(ii) The use of appropriate language

(iii) The use of concrete teaching aids

(iv) The use of concrete or direct real-life situations and examples

(v) Scaffolding – the use of qualitatively different teaching strategies

These categories are important in this discussion as they assist in explaining the contextual circumstances and conditions that constituted the teacher-learner situation in the Grade 7 classroom, on one hand. On the other hand, they assist to complete the framework for analysing effective teaching of mathematics in an inclusive classroom by enabling one to understand teaching which enables learning, i.e. the construction of meaning and concept formation in mathematics.

This discussion will provide a more analytic picture of the manner of interaction in the Grade 7 classroom.

(i) Groups

The teacher grouped the learners into three groups which remained the same in all five lessons. Each group consisted of five members: four physically disabled learners and one able-bodied learner. During the learners' interviews, one of the interviewees, a stammerer, indicated that he was comfortable working with the group he worked with. As such, his emotions were nurtured. The interview went like this:

I: But you were talking all the time, explaining to the others?

M: Yes, I was. I wanted to.

I: Doesn't your speech disturb you when you explain something to the other learners?

M: "Yes, it disturb me". [3]

I: How does it disturb you?

M: Sometimes I forget what I want to say and people don't have the time to listen to me.

I: To listen to you?

M: Yes, it's like I'm taking their time.

I: Do you mean they don't have patience?

M: Yes, I wanted to say that.

I: But those in your group listened to you?

M: Yes, that's why I like working with them.

I: You like working with them?

M: Yes, they listen when I say something and they don't tell me to be "quick".

I: Oh! Did you choose to work with them?

M: No, Teacher knows they have patience for me.

I: So, you mean it's the teacher who decided you worked with them?

M: Yes, and I also like working with them.

The grouping of learners in this way was beneficial to all learners. The able-bodied learners spontaneously took the responsibility of handing out worksheets and distributing learning aids to the other group members. The physically disabled learners were involved in appropriate physical activities. They read out instructions pertaining to experiments the groups had to perform; they recorded the measurements they had taken; they took decisions on the number of wooden cubes and dice they would use in their groups and they reported to the whole class on the findings they had made in their respective groups. One physically disabled learner who cannot lift a book because of very weak muscles and arms (a muscular dystrophy sufferer) dominated his group's discussions until another group

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